AD-A095 730 LOGICON INC SAN DIEGO CA TACTICAL AND TRAINING SYSTE--ETC F/G 5/9
LANDING SIGNAL OFFICER (LSO) LABORATORY SYSTEM SOFTWARE.(U)
NOV 80 J T HOOKS, E A BUTLER, M J REISS N61339-78-C-0151
UNCLASSIFIED 8581-0005AB NAVTRAEQUIPC-78-C-0151-1 NL

1 OF 1
AD
A095730

END
DATE
FILMED
3-81
DTIC

TW

(12)

REPORT NAVTRAEQUIPCEN 78-C-0151-1

LEVEL II

AD A095730

LANDING SIGNAL OFFICER (LSO) LABORATORY SYSTEM SOFTWARE

J. Thel Hooks, Edward A. Butler,
Mitchell J. Reiss and Rohn Petersen
Logicon, Inc.
Tactical and Training Systems Division
Post Office Box 80158
San Diego, California

November 1980

Final Report for Period
September 1978 - September 1980

DoD Distribution Statement

Approved for public release;
distribution unlimited.

NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

TW

81 3 2 049

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVTRAEQUIPCEN 78-C-0151-1	2. GOVT ACCESSION NO. AD-A095 734	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Landing Signal Officer (LSO) Laboratory System Software		5. TYPE OF REPORT & PERIOD COVERED Final Report. Sept 1978 — Sept 1980
		6. PERFORMING ORG. REPORT NUMBER 8581-0005AB
7. AUTHOR(s) J. Thel Hooks, Edward A. Butler, Mitchell J. Reiss, Rohn J. Petersen		8. CONTRACT OR GRANT NUMBER(s) N61339-78-C-0151
9. PERFORMING ORGANIZATION NAME AND ADDRESS Logicon, Inc. P.O. Box 80158 San Diego, CA 92138		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 7754-2P1
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Training Equipment Center Orlando, FL 32813		12. REPORT DATE November 1980
		13. NUMBER OF PAGES 76
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Automated Adaptive Training
Automated Speech Technology
Carrier Landings
Landing Signal Officer (LSO) Training System
Speech Recognition

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes research activities associated with automated LSO training system concepts. The primary activity involved development and demonstration of a laboratory LSO training system. The laboratory system was designed to enable LSO task interaction with simulated carrier approaches. This was accomplished through graphics simulation, automated speech recognition and computer control pilot and aircraft functions. The system also included the training functions of automated prompting, performance feedback and LSO performance evaluation.
(Cont.)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Cont

Another activity involved experimental use of the AWAVS visual simulation research facility at NAVTRAEQUIPCEN. Also included in this report are study results and recommendations for the capabilities and utilization of an experimental prototype LSO training system.

FOREWORD

The system described by this report has not been validated. This report represents, instead, the efforts which led to the implementation of a laboratory system which will allow testing of the concept of a closed-loop LSO training system. Validation and refinement of the software described in this report will provide data for use in the development of an operational LSO training system.

R Breaux

R. BREAUX, Ph.D.
Scientific Officer

Accession For		
NTIS GRA&I	X	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution/		
Availability Codes		
Dist	Avail and/or Special	
A		

PREFACE

The authors are indebted to the many Landing Signal Officers who contributed their time and ideas to this research effort. LCDR Bill Gruver, Officer-in-Charge of the LSO Phase I School, was particularly helpful in the coordination of access to LSOs and in providing insight to real-world LSO training considerations.

TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION	7
II	PROGRAM OBJECTIVES	8
III	PROGRAM ACTIVITIES	10
	Laboratory LSO Software (IES)	10
	AWAVS Experimentation	32
IV	CONCLUSION	35
	LSO Training System Concepts	35
	Laboratory LSO Training System	41
V	RECOMMENDATIONS	42
BIBLIOGRAPHY		44
APPENDIX A	IES SCENARIOS	47
APPENDIX B	LSO SOFTWARE QUESTIONNAIRE	53
APPENDIX C	AWAVS EXPERIMENTATION	57
APPENDIX D	EXPERIMENTAL PROTOTYPE LSO TRAINING SYSTEM	68

LIST OF ILLUSTRATIONS

Figure	Title	Page
1	Laboratory LSO Training System, Interactive Experiments System (IES)	11
2	IES Graphic Display	13
3	Glideslope, Lineup and Range Zones	16
4	Revised IES Graphics	20
5	Performance Data Printout	22
6	Generic LSO Training System Functions	23
7	Performance Results	29
C-1	Design for Experiment 1	58
C-2	Design for Experiment 2	62
C-3	Probability of Making a Call	66
C-4	Probability of Reporting Deviation	67
D-1	Generic LSO Training System Functions	72

LIST OF TABLES

Table	Title	Page
1	Areas of Investigation	9
2	Performance Model in IES	14
3	LSO Voice Calls in IES	15
4	IES Enhancements	19
5	Summary of IES Features	24
6	LSO Training System Alternatives	37
7	Procurement Decision Factors	39
C-1	Procedure for Experiment 1	61
C-2	Analysis of Variance Table - Data Relating the Probability of Making a Call.	68
C-3	Analysis of Variance Table - Data Relating the Probability of Reporting a Deviation	69
C-4	Differences Among Means for the Treatment Levels for the Field of View Main Effect	69

SECTION I

INTRODUCTION

This report describes research activities and results which are concerned with application of modern training technology to a Navy LSO training problem. The Navy's LSO training program is producing insufficient numbers of skilled LSOs. The level of skill acquired in training is also under scrutiny. An earlier study sponsored by the Naval Training Equipment Center (NAVTRAEQUIPCEN) analyzed the LSO Job and training process[1]. That study resulted in the identification of LSO training program shortcomings and provided recommendations for improvement, including the description of an automated LSO training system concept. Based on recommendations from that study, a program was initiated to develop and utilize a laboratory LSO training system for the investigation of automated LSO training system concepts.

The laboratory training system study is the subject of this report. It was conducted in two phases. The initial phase covered the time frame between September 1978 and September 1979. The follow-on phase was performed between October 1979 and September 1980. There have been other related activities sponsored by NAVTRAEQUIPCEN during this time frame. Subjects of these studies include modelling LSO "waving" behavior, identification of global measures of LSO "waving" effectiveness and evaluation of the LSO Reverse Display, an operational device designed to support LSO training. NAVTRAEQUIPCEN has also been conducting in-house studies of LSO training strategies and applications of computer aided LSO instruction.

The results of this program have confirmed the feasibility of the automated LSO training system concept and have provided positive indications of potential training effectiveness for such a concept.

Subsequent portions of this report describe program objectives, activities, results and recommendations for future program direction. An appendix is also provided which describes the recommended performance capabilities for an experimental prototype LSO training system.

---

1. J.T. Hooks, E.A. Butler, R.A. Gullen and R.J. Petersen, Design Study for an Auto-Adaptive LSO Training System, NAVTRAEQUIPCEN 77-C-0109-1, December 1978.

SECTION II

PROGRAM OBJECTIVES

The purpose of this program, as stated in the Study Specification, was to "... empirically refine and validate the functional requirements and performance specifications for an automated adaptive LSO training system...." This was to be accomplished "... through the development, implementation and utilization of a laboratory system." Program activities toward this purpose covered two separate phases, an initial contract effort and a follow-on contract effort.

The objectives of the initial contract phase were to make significant progress in the resolution of LSO training system design uncertainty and to demonstrate the automated LSO training system concepts which were derived in an earlier study by Hooks and others (1978). In support of these objectives, several areas of investigation were planned. They are delineated in Table 1. Of primary interest were the concepts of a "pilotless" LSO training system, automated LSO performance measurement, and the requirements for visual simulation in an LSO training system. These were considered the most important issues in resolving the functional requirements for an automated adaptive LSO training system. System development time was greater than originally anticipated. This factor precluded comprehensive experimental investigations. Two issues, training transfer and adaptive LSO training strategies, were not addressed due to limitations in the capabilities which could be incorporated into the laboratory system.

The objectives of the second contract phase were based on results obtained from exercising the laboratory LSO software. The first objective was to enhance this system from two perspectives: perceptual characteristics of the display and instructional features. The second objective was to evaluate the merits of interactive decision-oriented instruction early in the LSO training cycle. A third objective was to evaluate the feasibility of limited instructorless LSO training. The final objective was to evaluate the utility of a simplified LSO decision-making model for early LSO training. There was also an underlying secondary objective in this contract phase, the evaluation of the system itself as a candidate part-task, LSO decision training device. Some success was obtained in meeting these objectives, but the results were limited from a scientific basis. Although the training effectiveness of the laboratory system was not validated, some insight was gained into directions for future research with automated LSO training system concepts.

TABLE 1. AREAS OF INVESTIGATION

System Level:	Training Transfer "Pilotless" Training System Feasibility
Visual Environment:	Instructional Feedback Display Artificial Cueing Resolution Requirements Aircraft Level of Detail Requirements Field of View Requirements
Pilot/Aircraft Modelling:	Pilot Skill Variation
Instructional Feedback	Relevant Feedback Content
Selection of Learning Alternatives:	Adaptive LSO Training Strategies
Performance Measurement:	Speech Recognition Techniques Applicability of LSO Behavioral Models

SECTION III

PROGRAM ACTIVITIES

The primary activities during this program involved the development and utilization of a laboratory LSO training system called Interactive Experiments System (IES). Another activity involved the experimental utilization of the Aviation Wide Angle Visual System (AWAVS), now called the Visual Technology Research System (VTRS).

LABORATORY LSO SOFTWARE (IES)

Development of software for a laboratory LSO training system was initially oriented to the demonstration of an automated LSO training system concept. This initial contract phase occurred between September 1978 and September 1979. Following that effort, a second contract phase was initiated to investigate more specific aspects within the LSO training system concept. This activity occurred between October 1979 and September 1980. The activities involved in these two phases are described below.

INITIAL PHASE. As mentioned earlier, this initial contract phase was oriented toward several areas of investigation. For IES, the primary focus was on development and demonstration of the concept of an automated system for LSO training: a "pilotless," closed-loop system allowing LSO interaction through automated speech recognition. Figure 1 depicts the equipment configuration of IES.

Development. Development of this system was based on a preliminary design presented in an earlier report by Hooks and others (1978). Hardware at NAVTRAEQUIPCEN for which IES was designed included a NOVA 1200 CPU, a NOVA 800 CPU with floating point, a VIP-100 voice recognition preprocessor, an interprocessor communication link (IPB), a shared disk featuring two removable and two fixed cartridges, a Megatek 5000 random scan graphics display, and a Talley Model 2200 line printer. Software design and development were accomplished by Logicon and NAVTRAEQUIPCEN personnel, using a government-owned Eclipse S-130 at Logicon. IES was designed such that Logicon personnel produced the software for system elements to be run on the NOVA 800 and NAVTRAEQUIPCEN personnel developed the software elements for the NOVA 1200. This minimized system testing and integration problems during development. Early into the development effort it was noted that there would be limitations in CPU capacity which would limit the number of available training functions. Therefore development efforts had to include functional priority considerations. As a result, IES capabilities were somewhat less than originally envisioned, and the operating system for the Nova 800 was changed from RDOS, a disk based system, to RTOS, a memory resident system; RTOS has fewer capabilities but is also less demanding of resources.

Software Description. The operating concept for IES was to allow the trainee to view a graphics portrayal of an approach, perceive the need for a voice call and input the call to the system. The system would then process the call, simulate and display pilot response, and record an evaluation of trainee performance. Thus, IES provides closed-loop LSO and pilot interaction in an instructional scenario-controlled environment.

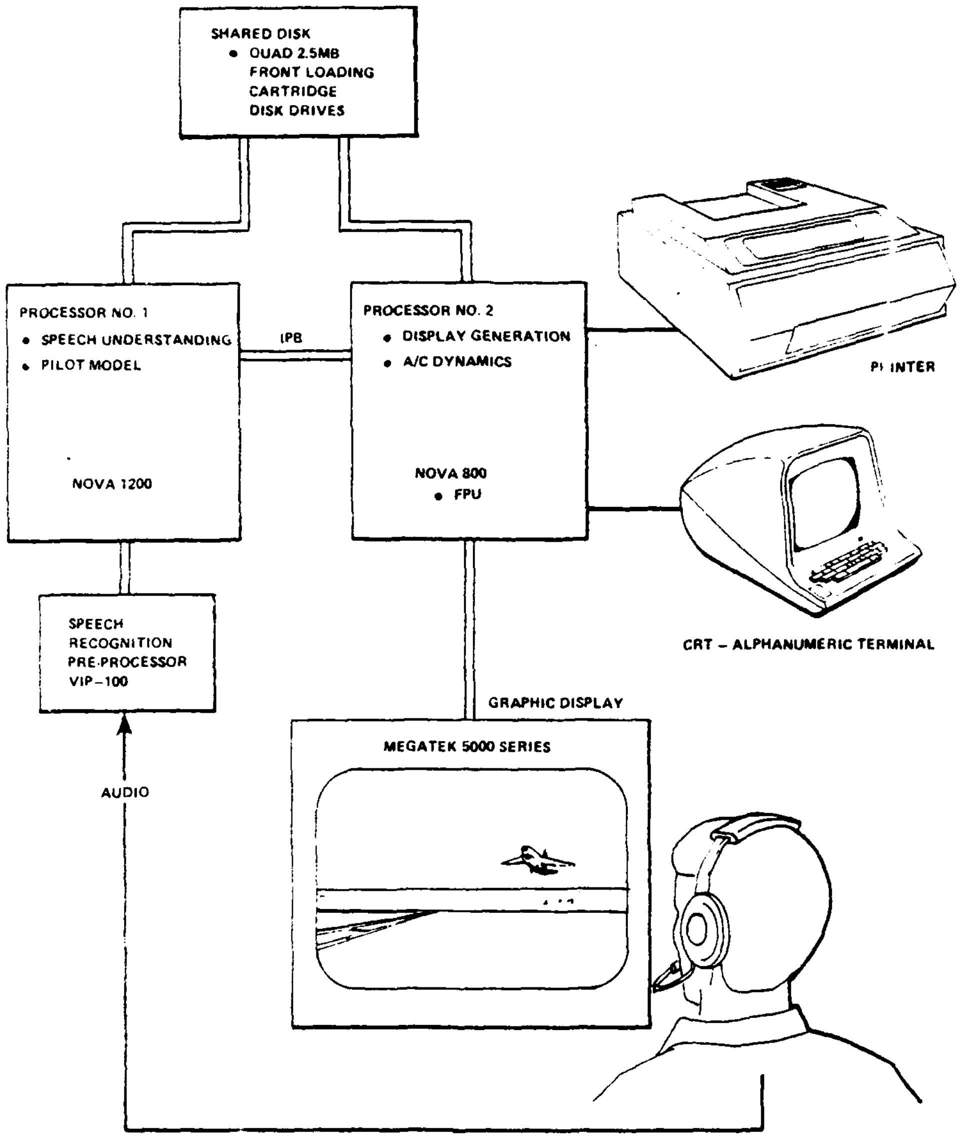

Figure 1. Laboratory LSO Training System Interactive Experiments (IES)

There are several major functional aspects to IES: graphic display of aircraft and approach scene, LSO performance evaluation, speech recognition, Aircraft/Pilot Model (APM), exercise control and performance data recording. Paragraphs below provide descriptions of system functions and an overview of system operations in its initial version.

The graphic system of IES provides a line-drawing depiction of an approaching aircraft and background scene including horizon, carrier deck outline and ship's wake. It also provides text messages and an aircraft position grid presenting dynamic glideslope, lineup and range information. The aircraft image has minimal fidelity, looking somewhat like a wire model airplane. This significantly minimizes graphic processing requirements. The visual field of view covers about 60 degrees (horizontal) and the aircraft image is updated approximately 12 times per second. Figure 2 is an annotated depiction of IES in the initial phase.

LSO performance evaluation is provided by correlating recognized voice call input to aircraft state parameters (including glideslope, lineup, angle of attack and range) to a pre-programmed model of correct performance. Table 2 provides a listing of 33 voice call and approach situation correlations which are incorporated into IES. This is essentially a significant simplification of the LSO behavioral model developed by Borden and McCauley (1978).[2] Performance evaluation in IES is a "snapshot" model which does not account for rates of aircraft parameter changes (such as sink and drift rate). However, the model implementation is such that it can be increased in complexity if IES were implemented on hardware with greater CPU resources. Another limitation to the initial version of performance evaluation is that "errors of omission" (e.g. no voice call when one is required) are not detected.

Automated speech recognition involves the collection of an LSO's voice patterns on each call which will later be used in training exercises. This is the interactive link between the LSO and the approach situation. IES has been designed to handle 23 standard LSO voice calls. Table 3 provides a listing of IES voice calls. Not all of them are used in the performance evaluation function.

The aircraft/pilot model (APM) function guides the simulated aircraft flight dynamics based on pre-programmed maneuver commands or commands based on LSO voice calls. The approach speed of the aircraft is fixed at 110 knots of closure. Glideslope and lineup positioning vary between a series of zones which reflect various deviations from optimum positioning during approach. Rates of glideslope and lineup positioning changes are variable pre-programmed values. Lineup positioning changes include aircraft roll movement for change initiation and completion. Angle of attack (AOA) is reflected in pitch variation between optimum (about 10 degrees nose up), fast (about five degrees nose up) and slow (about fifteen degrees nose up). Range is segmented into four zones which begin at one mile: "start," "in the middle," "in close" and "at the ramp." Figure 3 provides unscaled depictions of glideslope, lineup and range zone variations. APM also reflects pilot skill and responsiveness

---

2. G.J. Borden and M.E. McCauley, Computer Based LSO Carrier Aircraft Recovery Model (Progress Report), Human Performance Research, Inc., 1978.

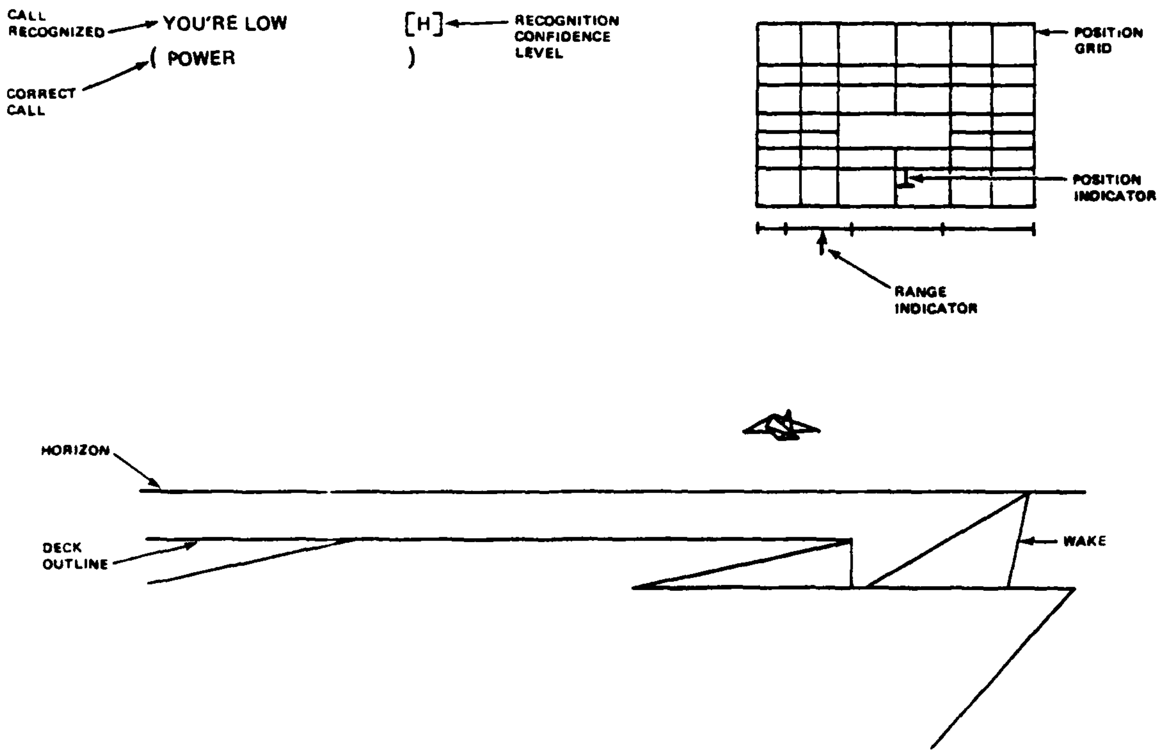

Figure 2. IES Graphic Display

TABLE 2. PERFORMANCE MODEL IN IES

Relevant Aircraft Parameters

Correct Call	Range	Glideslope	Line Up	AOA
"You're High"	Start	Very High	-------	----
"You're High"	Middle	Very High	-------	----
"You're High"	Close	Very High	-------	----
"You're Low"	Start	Low	-------	----
"You're Low"	Middle	Low	-------	----
"You're Lined Up Left"	Start	-------	Left	----
"You're Lined Up Left"	Middle	-------	Left	----
"You're Lined Up Right"	Start	-------	Right	----
"You're Lined Up Right"	Middle	-------	Right	----
"You're Fast"	Start	-------	-------	Fast
"You're Fast"	Middle	-------	-------	Fast
"You're Slow"	Start	-------	-------	Slow
"You're Slow"	Middle	-------	-------	Slow
"Power"	Close	Low	-------	----
"Power"	Close	-------	-------	Slow
"Right for Line Up"	Close	-------	Left	----
"Left for Line Up"	Close	-------	Right	----
"Waveoff"	Close	Low	Left	----
"Waveoff"	Close	Low	Right	----
"Waveoff"	Close	High	Left	----
"Waveoff"	Close	High	Right	----
"Waveoff"	Close	Low	-------	Slow
"Waveoff"	Close	High	-------	Fast
"Waveoff"	Close	-------	Left	Slow
"Waveoff"	Close	-------	Left	Fast
"Waveoff"	Close	-------	Right	Slow
"Waveoff"	Close	-------	Right	Fast
"Waveoff"	Ramp	Low	-------	----
"Waveoff"	Ramp	High	-------	----
"Waveoff"	Ramp	-------	Left	----
"Waveoff"	Ramp	-------	Right	----
"Waveoff"	Ramp	-------	-------	Fast
"Waveoff"	Ramp	-------	-------	Slow

Note: "-------" indicates that this parameter is ignored by the system.

TABLE 3. LSO VOICE CALLS IN IES

Roger Ball
You're A Little High
You're High
You're A Little Low
You're Low
You're Going High
You're Going Low
You're Lined Up Left
You're Lined Up Right
You're Drifting Left
You're Drifting Right
You're Fast
You're Slow
Check Your Line Up
Don't Settle
Don't Go Low
Don't Climb
Don't Go High
A Little Power
Power
Right For Line Up
Left For Line Up
Waveoff

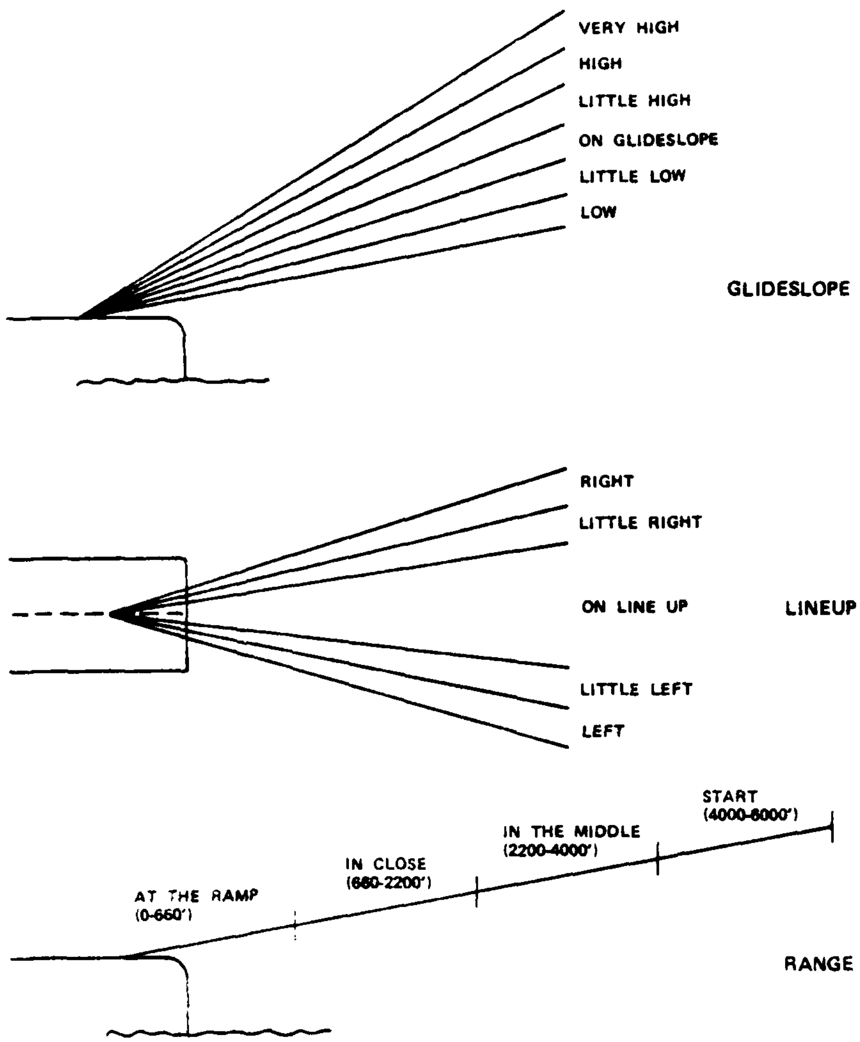

Figure 3. Glideslope, Lineup and Range Zones

variations based on pre-programmed scenario inputs. Skill is reflected in the size of glideslope and lineup variation within a zone. Responsiveness is reflected by pre-programmed time variations between LSO voice call and aircraft response.

A primary influence on exercise control is the scenario selected by the operator. The scenario file contains a pre-programmed aircraft approach profile which has been designed for a specific training purpose. Maneuvers and changes in AOA are keyed in the scenario to range values. In the initial version of IES, text prompting messages are also pre-programmed, and display of the text is an operator option prior to starting an approach. Another influence on exercise control occurs when an LSO voice call is recognized by IES. For a correct voice call (as determined by performance evaluation), the aircraft responds with a pre-programmed maneuver to correct the existing deviation. Incorrect voice calls are ignored in the initial version of IES. The final influences on exercise control are operator options selected prior to commencement of an approach. In the phase one version, these include display of scenario text messages, display of performance feedback messages, display of aircraft position grid and determination of whether the aircraft will maneuver in response to LSO voice calls.

Performance data from an approach is saved and displayed at the operator's terminal at the end of approach and is available for printout at the end of a training session. Data available in the initial IES version includes scenario, LSO name, operator options selected, voice calls along with the aircraft parameters at the time of the call, correct call if call made was incorrect, aircraft parameters throughout the approach (at a sampling rate of about once every second), and an accounting of time spent by the aircraft in the various glideslope, lineup and AOA zones.

From an overall viewpoint, IES is a limited representation of all major functional elements of an automated LSO training system with the exception of automated, adaptive syllabus control.

<u>Utilization and Results</u>. After implementation the system was demonstrated to several fleet LSOs, and an informal test was conducted in-house at Logicon. Two subjects were used in the test, each having a Navy carrier pilot background, but no LSO experience. Over two days, each subject was sequenced through syllabus exercises. Syllabus sequencing was based on incremental introduction of waving skill components (glideslope, lineup, AOA and waveoff related calls). From the standpoint of system operability, the system tested successfully. From a training standpoint, however, several deficiencies were discovered.

a. One of the major discrepancies involved difficulties on the perception of approach deviations presented by the scenarios. This led to a conclusion that some amount of parameter exaggeration was required to enable meaningful presentation of waving situations.

b. Absence of a capability to detect errors of omissions significantly lessened the value of the performance evaluation function.

c. It became evident during testing that a freeze capability would aid effective conduct of a training session.

d. The aircraft position grid proved to be excessively cluttered, thus lessening its effectiveness as a perception aid.

e. The fact that the aircraft responded only to correct LSO calls turned out to be an excessive departure from real-world LSO waving interaction.

f. There were speech recognition difficulties which were attributed to lack of a contextual voice data collection (VDC) and to collection of data for more calls than were actually used. The VDC capability was implemented at NAVTRAEQUIPCEN but was not used in Logicon's in-house testing.

g. It was noted that the performance evaluation feedback feature would have been more effective if clarifying information could have accompanied the display of the correct call.

h. Design of the glideslope and lineup "zones" to converge at the optimum touchdown position significantly degraded the depiction of deviations for the "in close" and "at the ramp" segments of the approach, precluding variations in the final results of the approach. The system was thus unable to provide additional feedback on the effectiveness of LSO control in the terminal portion of the approach.

i. There was some question regarding the fidelity of the aircraft image from a training standpoint.

j. It was also noted that some form of evaluative feedback should be presented to the subject by the system following the approach, in order to enhance learning rate.

Another result of testing and demonstration of the system to skilled LSOs was the realization that the laboratory system with refinement, has significant potential as an introductory, part-task LSO decision training system. It could provide limited interactive training in an instructional setting such as the LSO Phase I School.

SECOND PHASE. In response to the results obtained from initial utilization of IES, software revision and IES testing, in accordance with the program objectives stated earlier, were conducted next.

Development. Since the software revisions were directed at increasing the capabilities of IES, the initial efforts involved identification of candidate enhancements and the structuring of overlays in IES to increase available memory. A functional specification of highest priority enhancements was developed and the software revisions were designed and implemented incrementally. As in the initial contract phase, the revision effort involved Logicon and NAVTRAEQUIPCEN programmers. The functional aspects of the system which were revised included a graphic system, performance evaluation, APM, exercise control and performance data recording. The scenario files were also modified and additional scenarios were added to IES. The results of the revisions follow.

Software Description. The operating concept of IES remains as described for the initial contract phase. The revisions for this contract phase are outlined in Table 4 and discussed in the paragraphs below.

Freeze was implemented in the revised IES. This is initiated through the operator terminal. From the "freeze" state, operator action can be taken to either resume the approach to its completion or terminate the approach.

TABLE 4. IES ENHANCEMENTS

Freeze
Prompt and Feedback Messages
Detection of Voice Call Omissions by Performance Evaluation System
Graphic System Enhancements
Aircraft Response to Selected Incorrect Calls
Revision of Glideslope and Lineup Zone Origin
Exaggeration of Deviations
Approach Results Display
Revision of Performance Summary Data

During freeze, text messages and aircraft position grid remain displayed. During freeze, an enhanced aircraft image is displayed.

Prompt and feedback text messages were expanded to provide clarifying information in terms of relevant aircraft approach parameters. For example, if the call "You're Low" was recognized, but "You're High" was the correct call, the relevant parameters of range and glideslope would be displayed. The display of prompt messages was revised such that they are now data-driven and not controlled by pre-programmed scenario text commands. If the prompt option is selected, the correct call and relevant parameters are displayed as soon as the aircraft reaches a state requiring a call.

Performance evaluation accounts for "errors of omission" in the revised IES. If a call is not made within a brief time period after the aircraft reaches a state requiring a call, an LSO performance error is noted by the system. If the feedback message option is selected, information as described above for a prompt is displayed.

There were several revisions to the IES graphic system. One mentioned earlier is the enhanced aircraft image displayed during freeze. This image is similar to the A-7 aircraft and provides perceivable separation of wing and horizontal stabilizer. The run-time aircraft image was also improved slightly. Additional carrier landing area markings were incorporated into the background scene. Clutter in the aircraft position grid was reduced. Figure 4 is a depiction of the revised IES.

The capability was added for the aircraft to respond to selected incorrect voice calls. These include "waveoff," "power," and "right/left for lineup", which are imperative LSO calls for which pilot response is very likely even if incorrectly used by the LSO.

The origin for glideslope and lineup zones was revised. The initial version of IES had the zone originating from the ideal touchdown point on the deck. This did not allow for deviations on touchdown, nor did it provide adequate perceptual variation in the final portion of the approach. The zone origin has been moved so that glideslope and lineup deviations on touchdown can vary and be discriminated by the system for reporting approach results to

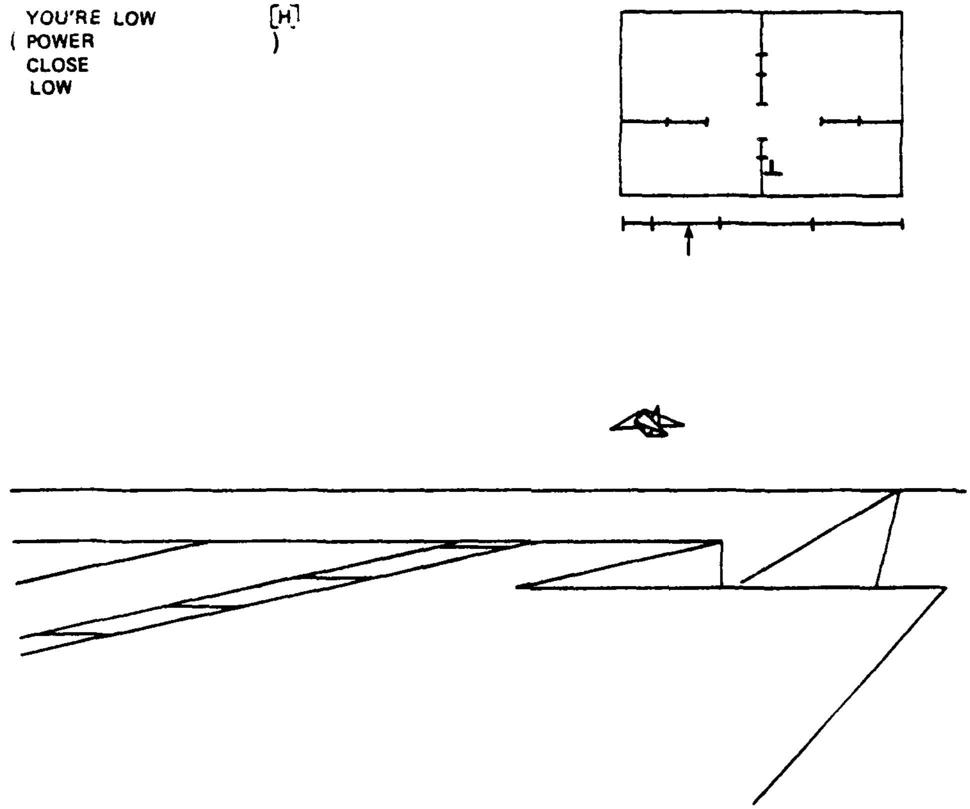

Figure 4. Revised IES Graphic Display

the LSO. In response to difficulties reported in perceiving glideslope, lineup and AOA deviations, the sizes of the deviations were exaggerated and optimum glideslope was rotated upward.

At the end of an approach, touchdown dynamics are presented in the text area of the display. Parameters presented include arresting wire (where a 3 wire is optimum), lineup position (only if other than optimum) and angle of attack (only if slow or fast). If the aircraft is too high to catch a wire the landing result presented is "bolter" (landed but did not catch a wire) or "waveoff" (too high to touch the deck).

The system for performance summary data recording, displaying it (on the operator terminal) and making it available for print-out was revised. The periodic recording of aircraft parameters throughout the approach was deleted. The summary of LSO voice calls correlated to aircraft parameters was streamlined and revised to present word and acronym descriptions instead of number codes. The zone accounting data was also reduced. Figure 5 shows a sample performance summary print-out.

As mentioned earlier, IES is a laboratory representation of automated LSO training system concepts reported earlier by Hooks and others (1978). Figure 6 excerpted from the report, presents a generic functional architecture for an automated LSO training system. Table 5 presents a summary of IES features correlated to that functional architecture.

Utilization. After implementation of software revisions, IES was informally exercised with three subjects at Logicon's San Diego facility. Time and equipment availability constraints precluded extensive experimentation. The intent of this activity was to obtain performance data and subjective commentary which would help identify potential strengths and limitations of IES and the LSO training system concepts represented by it. Each subject received training in the basic LSO decision skill subset which was designed into IES. Questionnaire and system performance evaluation data was recorded during the study to evaluate system capabilities and potential training merits.

The training consisted of four sessions for each subject. Each session was approximately one and one-half hours in duration. Two of the subjects were Navy pilots without LSO skills; one was a very experienced carrier pilot, the other very inexperienced. The third subject was a highly experienced LSO.

There were several procedures in the study which were common to each session. Each session included four portions: session briefing, training, testing, questionnaire completion. During the session, the subject was allowed to retain a handout containing system and training information for easy reference. Midway through the training portion of the session and just prior to testing, the subject was given a break from session activities. During testing, the system operator manually recorded voice calls when speech recognition errors occurred.

The testing portion of each session involved having the subject "wave" 20 scenarios without the aircraft position grid and with only speech recognition feedback messages available. The system operator provided no verbal feedback to the subject regarding performance during testing. The test always included

```
NAME: THEL                     DATE:  5/22/80

OPTIONS: HUD - NO
          MESSAGES - PHRASE RECOGNITION ONLY
          AIRCRAFT RESPONSE - YES

CALL SUMMARY: CORRECT -    3
              INCORRECT -    0
              MISSED -   2
              NOT RECOGNIZED -    0

APPROACH RESULT: 3 WIRE     LEFT

APPROACH SUMMARY - SCENARID:04/21/80 001PT
CALL [SUS CONF]                     CORRECT CALL               R        GS   LU   AOA
NONE                     [L]        YOU'RE LINED UP RIGHT      MIDDLE   ON   RI   ON
YOU'RE LINED UP RIGHT    [H]        YOU'RE LINED UP RIGHT      MIDDLE   ON   RI   ON
RIGHT FOR LINEUP         [H]        RIGHT FOR LINEUP           CLOSE    ON   LE   ON
NONE                     [L]        WAVE OFF                   RAMP     ON   LE   ON
WAVE OFF                 [H]        WAVE OFF                   RAMP     ON   LE   ON
TOTAL COUNTS =  82
COUNTS - GLIDESLOPE ZONES:
        LO=  0 LL=  0 ON= 82 LH=  0 HI=  0 VH=  0
COUNTS - LINEUP ZONES:
        LE= 13 LL=  5 ON=  9 LR= 29 RI= 26
COUNTS - ANGLE OF ATTACK:
        FA=  0 ON= 82 SL=  0
```

Figure 5. Performance Data Printout

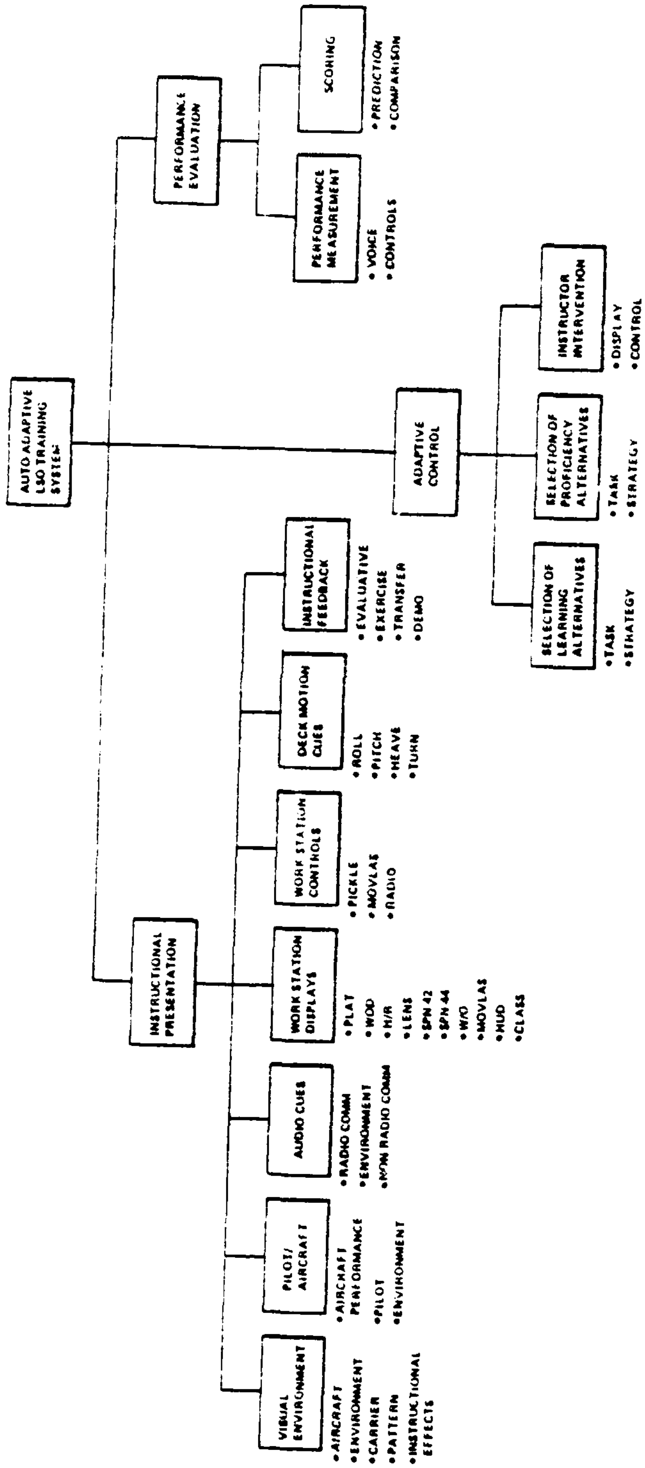

Figure 6. Generic LSO Training System Functions

TABLE 5. SUMMARY OF IES FEATURES

INSTRUCTIONAL PRESENTATION

a. Visual Environment

1. generic aircraft outline provided during approach; at freeze the outline switches to one with similarity to the A7 aircraft

2. day scene operating environment with depiction of ship's wake; field of view of about 60 degrees

3. generic carrier deck outline with centerline and "ladder line" markings; flush deck LSO platform

4. instructional effects include cueing aid for aircraft positioning (glideslope, lineup, range) and text messages for feedback and prompting

b. Pilot/Aircraft

1. simplified performance characteristics included fixed approach speed, limited variations in AOA (fast, on, slow), limited variations in sink and drift rate, limited correlation of roll to lineup changes, no correlation of pitch to glideslope changes

2. "zones" established for glideslope, lineup and AOA deviations for control of variations in aircraft maneuvers

3. pilot characteristics limited to size of deviations within zones (small, medium, large) and variations in response rate for maneuvers (fast, medium, slow)

c. Audio Cues - not provided

d. Workstation Displays - not explicitly provided, however cueing aid has functional similarity to LSO HUD

e. Workstation Controls - microphone provided for LSO communications to the pilot

f. Deck Motion Cues - not provided

g. Instructional Feedback - through operator options, performance feedback and prompting are available

ADAPTIVE CONTROL

a. Selection of Learning Alternatives - automated capability not provided

b. Selection of Proficiency Alternative - automated capability not provided

TABLE 5. SUMMARY OF IES FEATURES (CONT'D)

c. Instructor Intervention

1. instructor (operator) displays limited; over-the-shoulder observation of student display, own CRT display of options selected and end of run summary data (approach results and student performance)

2. instructor (operator) control limited; scenario selection, preselection of instructional options (prompting, feedback, cueing aid, aircraft response), freeze during run, re-run approach

3. data automatically recorded for each approach (operator selections, student performance, approach results) and available in hard copy through a line printer

PERFORMANCE EVALUATION

a. Performance Measurement

1. speech recognition for limited LSO calls

2. detection of aircraft state parameters

3. accountability of aircraft positioning in "zones"

b. Scoring - determination of correctness of LSO call (or lack of call) with respect to aircraft state parameters the same 20 scenarios. However, they were presented in a different sequence each time. Ten of the scenarios were selected from the 21 basic training scenarios used in the training portion of the study. The other ten involved more complex, multi-dimension deviations modelled after typical unsuccessful approach profiles (those which lead to bolters, hard landings and ramp strikes). The test did not include any "catch trials." Descriptions of the training and testing scenarios are presented in Appendix A.

The questionnaire completed by the subjects consisted of the same questions for each period. Of primary interest were problems experienced with IES, suggested IES improvements, ease of detecting deviations and learning achieved during the session. At the end of the final session, additional questions regarding the subject's perceptions of overall learning achievements, IES instructional strengths and potential IES utilization concepts were presented. A copy of the questionnaire is presented in Appendix B. Questionnaire results are discussed later in this section.

All subjects received the same testing and all completed the questionnaire. The two non-LSO subjects received the same briefing and training portion of each session. The experienced LSO subject observed during each session of another subject. Following this observation effort, he received a brief practice period with the 21 basic training scenarios prior to being tested. The four sessions experienced by the non-LSO subjects are described below.

In the <u>first session</u> the subject was given a comprehensive briefing concerning the study, IES and the training to be accomplished. A system and training information handout was also provided to him for reference. Following this the subject observed several approaches on IES for familiarization. The next step was voice data collection (VDC) for the 10 LSO calls to be used in training. VDC was accomplished through visual prompting from an alphanumeric CRT terminal, with four repetitions of each phrase and voice validation. The training portion of this session consisted of IES prompted presentation of all 21 basic training scenarios. The aircraft position grid was available for each approach and the system operator provided verbal preprompting prior to each approach. Testing and questionnaire completion finished the session.

For the <u>second session</u>, the subject was given a refresher briefing on the system and the study. The specific scenarios to be emphasized in this session were also discussed. During this session, training focused on 10 scenarios which consisted of informative voice calls for glideslope, lineup and AOA deviation within "at the start" and "in the middle" range zones. Initially, each of the 10 scenarios was presented with verbal pre-prompting, real-time IES prompting and the aircraft position grid displayed. The second time through the same scenarios, there was no prompting, but IES feedback and the aircraft position grid were available. The final portion of training involved practice with the 10 scenarios plus presentation of several "catch trial" scenarios (those with slight deviations but not requiring voice calls). During practice, the only aids available were IES performance feedback messages. Testing and questionnaire completion finished the session.

In the <u>third session</u> the subject was again given a refresher briefing and specific scenarios to be emphasized were discussed. During the session, training focused on seven scenarios covering the imperative voice calls used with single lineup and glideslope deviations for "in close" and "at the ramp" range zones The initial portions of scenario presentation were as described in the second session. During the practice portion, training scenarios learned in the previous session, as well as "catch trial" scenarios, were also included. Testing and questionnaire completion finished the session.

In the fourth session the subject was again given a refresher briefing and specific scenarios to be emphasized were discussed. Training for this session focused on four scenarios which covered the "waveoff" call for multiple dimension deviation within the "in close" range zone. The practice portion of the session included nearly all of the 21 basic training scenarios plus a few "catch trials." Testing and questionnaire completion finished the session.

Several problems were encountered during utilization of the system. Approximately twenty-five percent of the LSO voice calls were not properly recognized by the speech recognition sub-system. This, in turn, caused frustration on the part of the subjects and required manual recording of unrecognized voice calls by the system operator. Unfortunately, the collection of voice data in a training context was not available when experimentation began. This is noteworthy since experience in other speech recognition-based training systems suggests that the voice data collection procedure influences the speech recognition performance. The interested reader is referred to Breaux and Goldstein (1975) and Breaux and Grady (1976). Also, in a follow-up investigation of the speech recognition subsystem, it was found that the threshold parameters were not optimized for naive system users. Another problem was that there was no performance data recorded for one of the subjects (inexperienced pilot) during his first two sessions. This was due to a temporary breakdown in the data recording feature of IES. There was an excessive delay of aircraft response to scenario-generated maneuver commands and to LSO voice calls. This discrepancy was noted prior to experimentation, and scenario maneuver timing was corrected to better reflect scenario training objectives. However, delays in aircraft response to LSO calls was not corrected. From a "waving" standpoint, the aircraft response delays lessened the realism of LSO-pilot interaction and was noticeable to the subjects. Another problem was that the output from performance evaluation was occasionally in error. For example, the recorded output of aircraft parameters did not always agree with the voice call which was recorded as correct or incorrect. This error was very infrequent but required extra attention to the performance data printouts during analysis.

Several other items concerning experimentation are considered worthy of comment. A few features of IES were not exercised during experimentation. The operator options to freeze, to rerun scenario, and to preclude aircraft maneuvers on LSO calls were not used. The training value of freeze and rerun were considered unquestionable and therefore were intentionally left out since this was such a brief study. Precluding aircraft maneuvers on LSO voice calls seemed more appropriate to a more extensive IES training program and was also intentionally left out of experimentation. The small sample of subjects used in this study was a shortcoming which could not be prevented due to time, equipment and subject availability constraints. More subjects and more training sessions per subject would have been desirable. However, since future experimentation with IES by NAVTRAEQUIPCEN appeared to be a realistic possibility, it was considered more important to LSO training research objectives to complete this study and report its results within the contracted cost and time frame.

Results. The results from experimentation with IES are described below. Discussion of recorded performance data is followed by discussions of questionnaires, then the performance and questionnaire results are discussed concurrently. In view of the extremely small sample, tests of statistical significance were not performed.

Overall performance measures by each subject improved after each session. Measurement of performance was defined during analysis by the percentage of correct calls within all call opportunities (calls made plus calls which should have been made.) Figure 7 depicts group and individual performance over the four sessions. It is noteworthy that the experienced LSO had the highest performance scores and the inexperienced pilot had the lowest, which is expected in a valid training system. Group performance data was also analyzed from several other perspectives.

Figure 7 also depicts performance by types of deviations over the four sessions. Notice that LSO performance with lineup deviations was the lowest, whereas performance for AOA and combinations of deviations tended to be higher than the others. High performance levels for combination deviations are probably due to the fact that a single call, "waveoff," was the only decision output for each of these situations in this study.

Figure 7 also depicts performance by range zone over the four sessions. Performance during "in close" tended to be below the others whereas "at the ramp" performance was well above the others in the final two sessions. The results of "at the start" performance are probably insignificant since there were very few deviations presented within that range zone. There are several likely reasons for poor "in close" performance. One is that there were more "in close" situations to be learned (8 out of 21 basic training scenarios). Additionally, for several deviation situations, the required calls differed significantly from "in the middle" and "at the ramp," making "in close" range zone estimation a more critical decision factor than for other range zones. These situations are delineated below:

Deviation	In the Middle	In Close	At the Ramp
Low	"you're low"	"power"	"waveoff"
Slow	"You're slow"	"power"	"waveoff"
Fast	"you're fast"	none	"waveoff"
Right	"you're lined up right"	"left for lineup"	"waveoff"
Left	"you're lined up left"	"right for lineup"	"waveoff"

The high performance levels for "at the ramp" were probably influenced by the fact that for any significant deviation in this range zone, the only correct call was 'waveoff."

From the perspective of calls used, performance quality with the "waveoff" and "you're slow" calls was dramatically higher than for any others. "Waveoff" call performance was probably influenced by the heavy training emphasis placed on its utilization. Eight of the 21 basic training scenarios

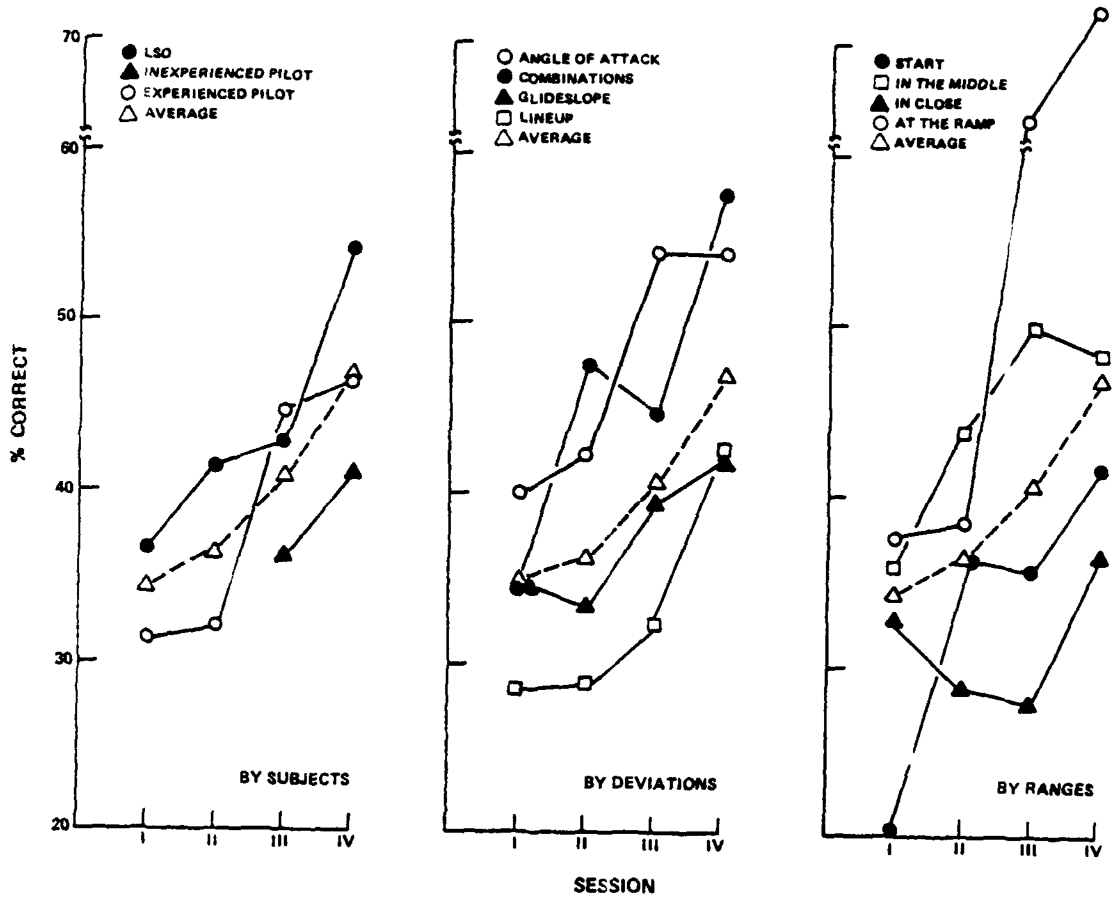

Figure 7. Performance Results

elicited the "waveoff" call. Additionally, many of the complex testing scenarios were designed to result in "waveoff" situations.

The data were analyzed to see if performance with the basic training scenarios portion of testing differed from that with the more complex scenarios. Surprisingly, the differences appeared inconsequential. Data was also analyzed to see if there were differences in performance between informative and imperative calls. The differences here also appeared to be insignificant.

In the questionnaire, subjects were asked to rate how well they could detect the various deviations within the various range zones. Glideslope deviations (high in particular) were rated easiest to detect and angle of attack deviations (fast in particular) were rated lowest. The subjects ranked "in close" as the range zone in which deviations were easiest to detect. The "middle" and "ramp" range zones were also rated fairly high. The "start" range zone was rated quite a bit lower than the others, as was expected. The subjects noted that it was difficult to perceive deviations due to the small size of the aircraft image at long ranges.

After each session the subjects were asked to identify the two decisions which were best learned during that session. The decision to call "power" for low glideslope in close was most frequently noted (four times). "Waveoff" was called for high, fast in close and for low, slow in close, and "you're lined up right/left" was called for lineup deviations at the start (three times each).

To help identify potential shortcomings in IES effectivenss, the subjects were also asked to identify two decisions for which the least learning occurred during each session. "Waveoff" for lineup deviations at the ramp was mentioned most frequently (five times). "Right/left for lineup" for lineup deviations in close was also mentioned frequently (four times).

At the end of the study the subjects were asked to rate how well they had learned the various decisions in the course of the study. The purpose of this question was to force the subjects to reflect upon the overall learning experience with IES. All subjects felt that they had "learned" or "learned very well" all decisions, with one exception. One subject was not sure if he had learned to use the call "waveoff" for lined up right at the ramp. His reason was based upon uncertainty in perceiving the deviation. Decisions related to lineup deviations at the start, in the middle and at the ramp, and glideslope deviations at the start received the lowest overall ratings.

The questionnaire also brought out several aspects of IES which the subjects felt needed improvement. Problems with speech recognition were most frequently noted. From the subjects' standpoint it caused frustration. It was also noted that automated performance measurement was degraded and that "instructor" (system operator) loading was high due to manually recording voice calls. Difficulty detecting the fast AOA deviation was also noted by all subjects. Two of the subjects commented that there should have been more "ok" approaches (no deviations) during training and testing. It was also suggested that the training portion of each session should include several complex, multi-deviation scenarios such as those presented during testing. The authors concur that these suggestions would have improved the reliability of study results. A "pickle" switch was suggested by two subjects. One subject suggested a large display and another was critical of aircraft image "jerkiness" in close. One subject suggested that the text messages would be easier to monitor if located nearer to the aircraft position grid. The authors concur that the suggested modifications to IES are potential improvements, but their cost-effectiveness is questionable.

The experienced LSO had some additional critique items of interest. He felt that training and performance evaluation should incorporate some precautionary calls such as "check your lineup," "you're drifting left," "don't settle," etc. These would help provide instruction in anticipatory decision skills in addition to the "snapshot" skills currently addressed by IES. It would also provide finer tuned control of aircraft dynamics by the LSO trainee since, when properly used, precautionary calls can preclude gross deviations. He was also critical of the roll dynamics associated with lineup deviations, since most real-world lineup deviations are more subtle. Increased feedback and instructional guidance to the student at the end of an approach was also suggested and was strongly concurred in by the authors. He felt that the horizon should be more prominent and that the lineup deviations and correction rates, in close and at the ramp, were excessive departures from realism. He also felt that a "ramp strike" should be one of the possible outcomes of a poor approach.

The subjects had several inputs regarding perceived strengths of IES for LSO training. All agreed that IES promotes a conceptual understanding of LSO decision skills. They felt that the interactive LSO task performance aspect of IES is a valuable introduction to waving, since it allows a trainee to gain early experience with the key elements of the LSO's decision loop: detecting, deciding and taking action. The inexperienced pilot felt strongly that his experience with IES in this study would be helpful to him in his early on-the-job LSO training. The aircraft position grid, in conjunction with the "snapshot" approach parameters associated with voice calls, encourage him to approach learning the LSO job from a "window" concept. He said that he will establish a series of spatial "windows" which he will use to guide his learning of when to use the various LSO voice calls. The experienced LSO also suggested that, if situations requiring a larger selection of voice calls were incorporated into IES training, this system could help promote voice call standardization in the LSO community. A quote from the experienced LSO is also noteworthy in providing insight into the potential value of LSO training system support to the LSO training program: "... the machine is extremely valuable. What it lacks in reproducing reality, it more than makes up for by providing student LSOs valuable decision making training which is never available in sufficient quantity in the fleet. It will eliminate the necessity of the Air Wing LSO concentrating on basics...."

There were some interesting correlations between task performance and questionnaire data. Of major interest to LSO training goals is task performance within the "in close" range zone. Pilot and LSO errors here can lead to tragic landing results. "In close" was the range zone in which the poorest performance was demonstrated, whereas the subjects felt that deviation detection was easiest in this area. As mentioned earlier, the number and complexity of the "in close" situations may have adversely affected performance. As Figure 7 (presented earlier) shows, "in close" performance appeared to be dramatically improving in the final session. This, coupled with the subjects' opinion of their detection skills, could indicate that there were too few training sessions to fully integrate the decision and action aspects of the task with detection. AOA was rated by the subjects as the most difficult type of deviation to detect, but performance with AOA deviations was well above average.

Regarding how well the subjects learned to "wave" various situations there were also some noteworthy correlations. Performance was very high for situations consisting of combination deviations. This compares favorably with the perception of the subjects that low, slow in close and high, fast in close (two situations leading to the "waveoff" call) were well learned during IES training. This is probably indicative that the subjects easily grasped the decision rule promoted by the training sessions that two major deviations in close require a "waveoff" call. Conversely, although the subjects felt that they learned well the situation low in close (leading to the "power" call), their performance for this was below average. This seems to indicate the difficulty subjects had in discriminating voice call requirement transitions by range for low deviations during approach, as discussed earlier. Situations consisting of lineup deviations in close and at the ramp were considered most difficult to learn by the subjects. Performance data for lineup deviations in close concurred with this perception. However, data for lineup deviations at the ramp indicated a high level of performance.

In summary, several results of IES utilization were encouraging. There was a definite imporvement in subjects' ability to perceive deviations from the original version of IES. The instructional feed back text feature of IES was also a definite improvement. Even though performance was less than expected, the learning progres over the four sessions was encouraging. The high level of performance and rate of learning for use of the "waveoff" call were particularly encouraging. The most encouraging result of all was the subjects' high level of receptivity to the automated LSO training system concepts of interactive, decision-oriented training. The fact that, after four training sessions, subjects were making correct calls only about fifty percent of the time was disappointing. Poor student performance for in close situations and poor system speech recognition performance were also disappointing results. In retrospect, the authors feel that the subjects should have received more taining sessions to better assess student learning progress.

For a field application there are several signifcant shortcomings to IES. Operation of IES was not designed for "turn key" utilization in a field training setting. The scope of instruction for field utilization is extremely limited, only encompassing minimal interactive LSO decision situations and voice calls. Flexibility for scenario revisions and expansion is very limited due to hardware constraints and software structure rigidity. Resolution of system shortcomings is possible with new hardware and revised software, but there is probably a significant cost consideration.

AWAVS EXPERIMENTATION

Experimentation was planned for the Aviation Wide Angle Visual System (AWAVS) at NAVTRAEQUIPCEN to investigate visual simulation requirements for an LSO training system. Subsequent paragraphs briefly describe AWAVS, experimental plans, experimentation activities and results. An expanded discussion of this activity is available in Appendix C.

AWAVS is a large domed visual simulation surrounding an aircraft cockpit (T-2). The aircraft simulation includes a motion base. AWAVS can project integrated imagery to the display area (about 180°) through two projectors, one for background scene, the other for target image. Projected imagery can come from either a model board or computer generation source. AWAVS was designed for research with visual simulation requirements for pilot training. For this experiment a computer generated A-7 aircraft data base was developed and a model aircraft carrier deck was constructed. AWAVS projected the carrier image through the background projector and the A-7 image through the target projector to provide a carrier approach scene from the LSO's perspective.

Original experimental plans called for investigation of several visual simulation variables including resolution, field of view and aircraft image level of detail. Testing was to be done under simulated day and night ambient light conditions. Due to system capability constraints, plans were reduced to looking only at field of view variations, and only under simulated day conditions. Constraints included: limited preprogrammed control of aircraft approach dynamics, no night aircraft image, and only a single image level of detail available. Additionally it turned out that only the highest system resolution allowed recognition of the aircraft image. The question actually addressed was whether field of view size made a difference in LSO perception and voice call performance. This was considered important since field of view size is a significant cost consideration for candidate visual systems.

In conducting the experiment, six highly skilled LSOs were used as subjects. Canned approach profiles were displayed to the subjects who were instructed to make LSO calls as if they were "waving" the aircraft. Various sizes of glideslope and lineup deviations were included in most of the profiles. Some profiles had no deviations. Only a portion of each approach was shown because the image could only be displayed while within a limited area defined by the position of the fixed target projector. The start ranges for the approaches varied between about 4000 and 2000 feet from the ideal touchdown point. Each approach terminated on LSO call or at about 1500 feet if no call were made by that range. Glideslope and lineup deviations varied between large, medium, small and none. If no call were made by the subject during an approach, he was asked whether he perceived any deviation at termination. At the end of the study, subjects filled out questionnaires and were interviewed by another senior LSO who assisted in the experiment.

Analysis of the experimental data in Appendix B revealed that field of view size had a statistically significant effect on LSO performance in detecting deviations, but not on making calls. It appears from inspection of Figure B-4 in Appendix B that best LSO performance was with the medium size field of view. There were quite a few incorrect detections by the subjects. Some were in terms of false alarms (saying there was a deviation when none existed). The overall probability of a false alarm was over 30 percent. Others involved errors in the direction of deviations (high versus low and right versus left). The glideslope error rate was five percent, and lineup was three percent.

Several confounding aspects of the experiment were noted by the authors, some of which were confirmed through questionnaire and interview responses. The LSO task of the subjects was somewhat unrealistic in that aircraft flight dynamics did not include roll or attitude changes. Deviations were smoothly depicted by a straight line vector. Both factors were caused by system constraints in the control of aircraft dynamics. There were criticisms of LSO task context in that the approach did not continue to touchdown, thus precluding approach results feedback, and there was no engine noise. There were strong criticisms of aircraft image quality (resolution) and the "fuzziness" of the background scene. The size of the aircraft image relative to range was questioned by the subjects (they felt it was too small). However, a double-check of dimensions confirmed the sizing to be correct. In rating realism, on a scale of 1 to 5 (where 1 = unrealistic and 5 = very realistic) the background scene was rated at slightly less than 3 and the aircraft image was rated at 3. There were also complaints about the small time frame of several approach profiles. Some were as short as 3 - 5 seconds prior to termination.

There were several other noteworthy comments from the subjects. Only half of the subjects felt that field of view variations affected their ability to wave the approaches. The subjects were also asked to rate the adequacy of the field of view variations for LSO training. On a scale of 1 to 5 (where 1 = inadequate and 5 = adequate), wide was rated at 4.5, medium at 4.2 and narrow at 3.2. There were no "inadequate" ratings given by the subjects. A few of the subjects who had seen the LSO Reverse Display felt that AWAVS image resolution was significantly poorer. However, they liked the openness of the AWAVS display area which permits two LSOs to view the scene. They felt that this was an advantage for LSO team training. All subjects agreed that a sophisticated visual simulation, as demonstrated by AWAVS and the LSO Reverse Display, would be beneficial to LSO training. This is in agreement with Hooks and McCauley.[3] With regard to an LSO training system application, the size of a projection system like AWAVS appears to be a potential disadvantage in terms of facility requirements.

The implication of the data and commentary provided in the paragraphs above is that the experiment did not successfully answer the question of visual system field of view requirements. However, the experience of working with AWAVS leads the authors to feel that its projection system is less desirable than a direct-view CRT system such as that incorporated in the LSO Reverse Display. The primary factors in this opinion are the resolution limitations, relatively high procurement costs and extensive facility requirements of a large-screen projection system.

3. J.T. Hooks and M.E. McCaulley, Training Characteristics of LSO Reverse Display, Technical Report 79-C-0101-1, NAVTRAEQUIPCEN, (in press).

SECTION IV

CONCLUSIONS

The authors conclude that an automated LSO training system is a feasible concept. The term "automated LSO training system" implies a stand-alone interactive system, consisting of high fidelity night visual simulation, automated speech recognition and software control of instructional situations. It does not imply an automated adaptive capability; that question remains unresolved. Subsequent paragraphs of this section discuss this and other conclusions which evolved from this study. The initial discussions address general LSO training system concepts and the final discussions address the laboratory system.

LSO TRAINING SYSTEM CONCEPTS

Support for the automated LSO training system concept mentioned above is based on several factors. It appears that IES utilization has proved the capability of LSO training system concepts for basic skill acquisition. The results of LSO Reverse Display evaluation, as reported by Hooks and McCauley[4], appear to support LSO training system benefits to higher level skill acquisition such as "waving" under pitching deck and Manually Operated Visual Landing Aid System (MOVLAS) conditions. Though IES was a relatively crude representation of a sophisticated automated LSO training system, there were positive indications of training effectiveness potential in this study: receptivity of subjects to its interactive decision-oriented training merits and their task performance improvements in a limited training period, especially in their grasp of when to use the "waveoff" call. From a system development standpoint, a potentially effective level of training capability was produced in a very constrained developmental environment (hardware and cost limitations). Therefore, greatly improved system effectiveness over that of IES is a reasonable expectation for a normal training system development situation. As reported by Hooks and McCauley, an adequate visual simulation capability has already been successfully demonstrated in the LSO Reverse Display. Although experimentation with AWAVS did not resolve visual simulation requirement uncertainties, it did provide insight into some of the limitations of a projection visual system to an LSO training application. The authors also feel that it is reasonable to anticipate that, with adequate computer resources, software control of situation presentation and LSO interaction can reach significantly higher instructional levels than those provided by IES. Although speech recognition difficulties were encountered with IES, the problems (non- optimized threshold parameters and absence of context VDC) have been identified and their resolution is feasible.

Based upon this study, as well as preliminary results from the LSO Reverse Display evaluation, there appear to be several functional aspects of an operational automated LSO training system which are needed for training effectiveness:

- provisions for LSO task interaction

4. J.T. Hooks and M.E. McCauley, Training Characteristics of LSO Reverse Display, Technical Report 79-C-0101-1, NAVTRAEQUIPCEN, (in press).

- night carrier visual approach scene simulation
- simulation of multiple aircraft types
- pitching deck simulation
- MOVLAS training capability
- "canned" or interactive preprogrammed approach scenario provisions to support specific learning goals
- graphic cueing aid(s)

There are also several functional aspects of an operational automated LSO training system which remain questionable. Some of the more important include:

- day carrier visual approach scene simulation
- automated adaptive syllabus control
- automated performance evaluation
- background sound simulation
- visual system field of view size

Later this report will present recommendations regarding resolution of these and other system design uncertainties through the development and testing of a <u>prototype</u> automated LSO training system. Appendix D delineates the recommended featues and capabilities for the <u>prototype</u> system, several of which are intended to aid in the resolution of <u>operational</u> system design uncertainties.

Based on study results, there also appear to be several LSO training system alternatives which singularly, or within a "family of training systems" concept, can increase LSO training program effectiveness. Table 6 outlines the alternatives. The paragraphs below describe envisioned capabilities, probable limitations and the estimated level of LSO skill acquisition for which each system is appropriate.

Alternative I is a demonstration system incorporating the dynamic presentation of approach situation scenes, possibly through movies, within a crudely simulated LSO workstation. This would essentially provide job familiarization to LSO trainees and would be a tool appropriate only to Phase I training. Alone, it would have only minimal impact on LSO training program effectiveness.

Alternative II is an interactive part task training system, similar to the laboratory LSO training system (IES) developed during this study, but with enhanced capabilities. The enhancements would consist of improved speech recognition and performance feedback plus an increase in the number of approach situations presented and their related voice calls. The instructional orientation of this device would be toward basic LSO decision-making

TABLE 6. LSO TRAINING SYSTEM ALTERNATIVES

I – Demonstration:	non-interactive approach scene "movies" work station representation LSO job familiarization
II – Part Task:	interactive enhanced version of laboratory LSO training system basic decision skills
III – High Fidelity Part Task:	interactive enhanced laboratory LSO training system basic decision skills basic perceptual skills
IV – Modified LSO Reverse Display:	interactive additional canned approaches multiple aircraft types instructor control of aircraft with "joystick" Phase III LSO training support
V – Universal LSO Trainer:	interactive night scene multiple aircraft types computer control of situations speech recognition Phase III and refresher training support
VI – Universal Adaptive LSO Training System:	interactive night scene multiple aircraft types computer control of situations speech recognition performance evaluation adaptive logic instructorless training Phase III and refresher training support

skills. Alone, this system should have a positive impact on LSO training program effectiveness by minimizing instructional attention to decision-making basics during on-the-job training (OJT). It should also be an effective Phase I training complement to the demonstration system mentioned earlier.

Alternative III is also an interactive part task training system. The major improvement over Alternative II is the incorporation of a high fidelity night visual simulation similar to that of the LSO Reverse Display. A single type of aircraft, such as the A7, would be realistically simulated, thus allowing instructional attention to perceptual as well as decision skills. This system would be beneficial to Phase I training. If located at multiple fleet sites, it should also provide limited support to Phase II and Phase III training. It would also have sufficient capabilities to support additional research into LSO training system concepts.

Alternative IV is a modified version of the LSO Reverse Display. LSO task interaction, with the pilot flying the A7E Night Carrier Landing Trainer (NCLT), would be retained. However, instructional control of situation presentation would be enhanced through an increase in the number of canned approaches available and through instructor control of aircraft dynamics with a "joystick." The scope of training would be increased through the simulation of multiple types of aircraft. This system should provide effective instructional support for a significant amount of Phase III LSO training. It may also prove beneficial in refresher LSO training.

Alternative V is an automated, interactive, stand-alone and universal LSO trainer. It would provide a night carrier approach scene similar in fidelity to the LSO Reverse Display. Other functional similarities to Alternative IV include multiple aircraft simulation, "joystick" and computer control of situations and speech recognition. Since it would be an original development, with more recent technologies than those in the LSO Reverse Display, the detailed features of the system would be more responsive to LSO training and instructor function requirements based on "lessons learned" from LSO Reverse Display utilization. This system should support Phase III and refresher LSO training and would likely support limited "instructorless" LSO trainee practice exercises. It would also support LSO training research due to its data collection features.

Alternative VI is an expansion of Alternative V to include automated performance evaluation and adaptive syllabus control. These features would reduce instructor loading and permit instructorless training for selected segments of LSO training. Anticipated limitations to the scope of instructorless training are based on current uncertainties regarding knowledge of valid performance measures throughout the range of LSO skills, and the unproven status of adaptive instructional techniques for complex skills, such as those of the LSO. This system should provide support to Phase III and refresher LSO training. It should also be an excellent tool for research into LSO task performance and learning strategies. This system will therefore [illegible] excellent candidate as an experimental prototype LSO training system which could provide decision-making guidance for whether more systems are needed and for what characteristics are really required.

There are several factors related to decisions regarding the procurement of LSO training systems such as those described above. Subsequent paragraphs discuss the factors identified in the course of this study. The factors are also outlined in Table 7.

TABLE 7. PROCUREMENT DECISION FACTORS

Cost:	development facilities maintenance student population
Training effectiveness:	acceleration of LSO training accident prevention
Accessibility:	siting timing of utilization travel funding
Utilization:	training program management instructor availability user attitudes

One of the major concerns of high-level Navy personnel is LSO training system(s) cost. A highly sophisticated automated LSO training system has a multi-million dollar cost potential just for initial procurement. This includes system design, development, testing, as well as availability of adequate supporting facilities. Additionally, there are long term maintenance cost considerations. This includes maintenance of system operating capabilities plus periodic update of system training capabilities and training program plans in response to changing LSO training needs. Concern has been expressed for the costs mentioned above, in view of the small size of the Navy's LSO population. There are approximately 300 LSO billets in the Navy, of which about one-third (90-100) are filled with trainees who are working toward the productive skill level of Wing LSO.

In contrast to cost concerns are considerations for LSO training program effectiveness. Shortages of skilled LSOs continue to exist in the fleet. Pilot retention, curtailed carrier operations, and the lengthy and inefficient LSO training process continue to be the major causes of this deficiency. Concerns continue to be raised regarding the actual skill levels of experienced LSOs, many of whom have had very limited exposure to demanding aspects of the LSO job such as pitching deck, MOVLAS, aircraft malfunctions and stressful operational situations. Only the LSOs operating aboard the USS Midway, stationed in Japan, have the opportunity for continual exposure to extensive carrier landing operations over a three-year tour of sea duty. Others are exposed to lengthy periods of inactivity between deployments and carrier landing operations while deployed. An LSO training system can supplement on-the-job training with interactive, instructionally-controlled "waving" experience. The authors and many experienced LSOs feel that such a system has the potential to accelerate basic skill acquisition, thus enabling a trainee to "get the pickle" earlier in his shipboard training program. The potential for increased experience with complex waving situations is another positive factor in support of an LSO training system. Improvements in carrier landing safety appear to be potential benefits from effective LSO training system utilization.

Accessibility to an LSO training system is a practical consideration which has significant cost and training effectiveness implications. Limited access to a training system, regardless of its effectiveness, minimizes its value. In the case of LSO training, timeliness of LSO training system utilization would be a very important training program effectiveness factor. The trainee should have access to the training system during FCLP work-ups and in close time proximity to carrier operations, in order to maximize transfer of skill acquisition between simulated and actual operating environments. The LSO population in the Navy has a wide geographical spread, encompassing five separate fleet population centers, as well as several Naval Aviation Training Command locations. Limiting the locations of an LSO training system, while keeping procurement costs down, causes difficulty in providing timely access for some trainees and increases travel funding requirements for system utilization. Additionally, there are LSO hardships to be considered. LSOs typically spend more time away from home during FCLP and carrier work-up periods than other fleet squadron pilots. Over two- thirds of all LSO billets and nearly all trainees operate from five fleet areas: Norfolk, Jacksonville, San Diego, Lemoore and Whidbey Island. Of these, the Norfolk (NAS Norfolk, NAS Oceana), San Diego (NAS Miramar, NAS North Island) and Jacksonville (NAS Cecil Field) have the largest LSO populations and therefore appear to be the most promising locations for LSO training systems, if limited systems were to be procured. Although Norfolk (about 70 LSOs) and San Diego (about 60 LSOs) have higher populations than NAS Cecil Field (about 50 LSOs), the LSO Phase I School at NAS Cecil Field is a favorable factor for that location. On the other hand, NAS Cecil Field already has the LSO Reverse Display device for limited support to LSO training. Procurement costs for five systems would be higher than for a single system, or for one system on each coast, but the tradeoffs between cost and training effectiveness are not as clear.

Another major consideration is training system utilization. A key factor in effective utilization would be training program management. The primary roles of management would include encouragement (or direction) of appropriate rates of utilization, monitoring of training system effectiveness, and implementation of training program and system revisions responsive to fleet needs. The recently established position of LSO Training Model Manager for the Phase I School Officer-in-Charge provides a vehicle for effective program management. The availability and motivation of instructor LSOs to conduct LSO training system instruction are other factors in effective system utilization. Air Wing Staff LSOs must be encouraged to utilize the system as an integral part of their training programs. Overall user (LSO and trainee) acceptance of LSO training system concepts is another important factor in effective system utilization. Since LSO trainees typically are very highly motivated individuals, their attitudes toward a training system will be strongly influenced by the attitudes of experienced LSOs. The positive receptivity of trainees to instruction, coupled with positive instructor attitudes, are very important ingredients to LSO training system effectiveness. Thus, promotion of positive user attitudes is an important system procurement consideration. Development and thorough testing of a prototype LSO training system would be an important step in building training system credibility for the LSO community.

LABORATORY LSO TRAINING SYSTEM

The authors tentatively conclude that, with significant enhancement, the laboratory LSO training system could be a beneficial addition to Phase I and Phase II LSO training as a part task training system. To meet this expectation improvements would be needed in speech recognition, scope of decision skill coverage by training scenarios and performance evaluation, and ease of instructor operability. The primary support for this conclusion was the subjects' high level of receptivity to the automated LSO training system concepts of interactive, decision-crientatated training. Additional experimental utilization of the laboratory LSO training system would be required for confirmation of its potential value.

The authors feel that this part task training concept falls far short of the training needs of the LSO community. Thus it should primarily be viewed as a relatively low-cost alternative to the prototype automated LSO training system discussed earlier.

SECTION V

RECOMMENDATIONS

Recommendations resulting from this study are concerned with a proposed prototype LSO training system, its features and its utilization. Research to date has been unable to quantitatively justify an automated LSO training system as a cost-effective improvement to LSO training. Based on the results of developing and exercising a laboratory LSO training system, the concept has proved feasible. Support for the concept from LSOs during this and other NAVTRAEQUIPCEN research programs indicate that such a concept can have strong positive impact on reducing the time required for LSO skill acquisition and on increasing the level of skill acquired. Thus, it is recommended that a prototype, automated LSO training system be developed for experimental validation and refinement of this concept, while, at the same time, providing support to the LSO training program.

The results of prototype system utilization should provide valid resolution to several major areas of uncertainty:

a. Is an automated LSO training system, a cost-effective enhancement to LSO training?

b. What features are actually required in such a system?

c. How should the system be employed for most effective support of LSO training?

d. How many systems are needed, and where should they be located?

Additionally, the authors feel that an automated LSO training system design oriented to the questions above would also be useful for continued research into future applications of automated speech technology and adaptive instructional concepts. Relevant issues include performance evaluation for complex speech-oriented jobs, instructorless training, and perceptual and decision skill acquisition.

Associated with the LSO training system questions presented above, are several recommended specific lines of inquiry to be addressed by the prototype system. The question of cost-effectiveness must first include a study of prototype LSO training system effectiveness. The subjective assessments of potential training benefits for the LSO training system concept, which have resulted from this study, must be objectively confirmed prior to subsequent studies. A study of training transfer from the prototype system to FCLP operations or preferably, to the carrier environment, is the recommended course of action for this confirmation. In conjunction with such a study, the levels of LSO skill acquisition, for which the training system concept can be applied, must be validated. This is necessary in order to ensure relevant instructional orientation for subsequent lines of inquiry. If training system deficiences are uncovered, the system or the methods of its employment must be successfully modified prior to the pursuit of any other lines of inquiry.

With regard to potential requirements for an <u>operational</u> LSO training system, there are several recommended areas of investigation. One area to be addressed is the potential interference to speech recognition from engine and background noise in the student station of an LSO training system. Another is to determine effective voice data collection techniques which can provide adequate recognition in stressful waving situations where voice characteristics may be significantly altered.

Determination of required visual simulation field of view should also be pursued since it has a significant influence on system costs. An experiment, such as the one attempted in this study with AWAVS, could be useful in this line of inquiry.

Actual instructor LSO activities while employing the training system should be analyzed for the determination of needed instructional support features and to identify the most effective instructional techniques and strategies. This type of study should also provide data to support the development or refinement of adaptive training logic.

The system should also be employed in the collection of skilled LSO and trainee task performance data to support validation of performance measures and refinement of automated performance evaluation concepts. LSO task performance data from earlier studies should also be employed in this effort.

Where to locate a prototype LSO training system is an important procurement question related to effective system utilization. Availability of sufficient LSOs and trainees for system evaluation studies is one factor. Another factor is availability of dedicated personnel for coordination of LSOs and system utilization, as well as to provide continuity of user (LSO) involvement with the studies. Since the LSO Phase I School and its staff have relocated to NAS Cecil Field, that location is recommended for the system. The LSO population for NAS Cecil Field is reasonably high and the LSO Training Model Manager and his staff can provide the personnel continuity required. NAS Miramar and NAS Oceana are also acceptable locations due to their high LSO population.

The recommended characteristics for the optimum experimental prototype LSO training system are quite extensive and are outlined in Appendix C. These characteristics coincide with the description of Alternative VI presented earlier in the report. It is recommended that consideration be given to a two-stage prototype system procurement. The first stage would involve the development and testing of the Universal LSO Trainer (Alternative V) described earlier in this report. Utilization of this system could provide answers to many questions concerning <u>operational</u> system procurement requirements. Utilization of this system's data collection capabilities could also provide a quantitative foundation for the identification of effective performance evaluation and syllabus control strategies. The second phase would involve the implementation of automated performance evaluation and adaptive syllabus control capabilities. The advantages of this recommendation include minimizing costs and time involved with acquiring an LSO training and research tool and reduction in the risks associated with development of automated capabilities for performance evaluation and adaptive syllabus control.

BIBLIOGRAPHY

Aviation Wide-Angle Visual System, Trainer Subsystem Design Report, NAVTRAEQUIPCEN Technical Report 75-C-0009-13 (Binghamton, N.Y.: Singer-Link Division, May, 1977).

Borden, G.J., The Landing Signal Officer: A Problem Analysis, Vols. I, II. Technical Report 785-1, Goleta, Calif.: Human Factors Research, Inc., May 1969.

Breaux, R., (Ed.), LSO Training R&D Seminar Proceedings, Technical Report, NAVTREAQUIPCEN IH-320, Naval Training Equipment Center, 1980.

Breaux, R. and Goldstein, I., Developments of Machine Speech Understanding for Automated Instructional Systems, Proceedings, Eighth NTEC/Industry Conference, Naval Training Equipment Center, 1975, 297-303.

Breaux, R. and Grady, M., The Voice Data Collection Program, A Generalized Research Tool for Studies in Speech Recognition, Proceedings, Ninth NTEC/Industry Conference, Technical Report, NAVTRAEQUIPCEN IH-276, Naval Training Equipment Center, 1976, 229-234.

Bunker, W.M., Training Effectiveness Versus Simulation Realism, Proceedings, Eleventh NTEC/Industry Conference, Technical Report, NAVTRAEQUIPCEN IH-306, Naval Training Equipment Center, 1978, 291-298.

Chambers, W.S., AWAVS: An Engineering Simulator for Design of Visual Flight Training Simulators, Journal of Aircraft, Vol. 14 (11), November 1977, 1060-1063.

Chatfield, Douglas C. and Gibcumb, Charles F., Optimization techniques for automated adaptive training systems, Technical Report NAVTRAEQUIPCEN 77-M-0575, 1977.

Chatfield, D.C., Marshall, P.H. and Gidcumb, C.F., Instructor Model Characteristics for Automated Speech Technology (IMCAST), Technical Report NAVTRAEQUIPCEN 79-C-0085-1, Naval Training Equipment Center, 1979.

Cream, B.W., Eggemeier, F.T., and Klein, G.A., A Strategy for the Development of Training Devices, Human Factors, 1978, 20(2), 145-158.

Erickson, D.P., Landing Signal Officer Guide and Training Plan, circa 1978.

Hooks, J.T., Butler, E.A., Gullen R.A. and Petersen, R.J., Design Study for an Auto-Adaptive Landing Signal Officer (LSO) Training System, Technical Report, NAVTRAEQUIPCEN 77-C-0109-1, Naval Training Equipment Center, 1978

Hooks, J.T., and McCauley, M.E., Training Characteristics of LSO Reverse Display, Interim Report, Technical Report NAVTRAEQUIPCEN 79-C-0101-1, Naval Training Equipment Center, in press.

Kelley, Charles R., What is Adaptive Training? Human Factors, 11 (6), 1969, pp. 547-556.

Lacy, J.W. and Meshier, C.W., Development of a Landing Signal Officer Trainer, Proceedings, First Interservice/Industry Training Equipment Conference, Technical Report, NAVTRAEQUIPCEN IH-316, Naval Training Equipment Center, 1979, 79-90.

Saunders, G.J., LSO, The Forgotten Man, Approach, Naval Safety Center, 1977.

Stueck, Phillip Gary, LSO Pilot Interaction Simulator. Naval Postgraduate School, Monterey, California, June, 1973.

U.S.Navy, Office of the Chief of Naval Operations, The Naval Air Training and Operating Procedures Standardization (NATOPS) Program Manual, Landing Signal Officer (LSO), 1975.

U.S. Navy, Commanding Officer Tactical Electronics Warfare Squadron 129. Carrier Aircraft Recovery Simulator (CARS) proposal letter. VAQ-129, NAS Whidbey, Washington, 26 May 1976.

APPENDIX A

IES SCENARIOS

TRAINING SCENARIOS

THE FOLLOWING SCENARIOS ARE DESIGNED FOR TRAINING SUBJECTS TO MAKE "APPROPRIATE" VOICE CALLS FOR VARIOUS TYPICAL AIRCRAFT APPROACH DEVIATIONS IN GLIDESLOPE, LINE-UP AND AOA. THE "APPROPRIATENESS" OF VOICE CALLS TO VARIOUS AIRCRAFT STATES IS BASED ON A SIMPLIFICATION OF AN LSO BEHAVIORAL MODEL. ACTUAL CALLS ELICITED BY THESE SCENARIOS ARE DEPENDENT UPON TRAINEE ACTION DURING THE APPROACH. IN OTHER WORDS, THE ACTUAL PROFILE FLOWN MAY DIFFER FROM ITS DESIGN DUE TO THE TIMING AND CORRECTNESS ASPECTS OF TRAINEE CALLS. THE DESCRIPTIONS BELOW ARE PROFILE DESIGNS WHICH MAY ONLY OCCUR IF THERE IS NO TRAINEE INTERACTION.

1. SCENARIO 001LT

   HIGH DEVIATION, START RANGE ZONE ELICITING THE CALL, "YOU'RE HIGH"

   AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA IMMEDIATELY STARTS A DEVIATION TO THE VERY HIGH GLIDESLOPE ZONE

2. SCENARIO 002LT

   LOW DEVIATION START RANGE ZONE ELICTING THE CALL "YOU'RE LOW"

   AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA IMMEDIATELY STARTS A DEVIATION TO THE LOW GLIDESLOPE ZONE

3. SCENARIO 003LT

   RIGHT LINEUP DEVIATION; START RANGE ZONE, ELICITING THE CALL "YOU'RE LINED UP RIGHT"

   AIRCRAFT STARTS ON GLIDESLOPE, LINEUP AOA IMMEDIATELY STARTS A DEVIATION TO THE RIGHT ZONE

4. SCENARIO 004LT

   LEFT LINEUP DEVIATION, START RANGE ZONE, ELICITING THE CALL, "YOU'RE LINED UP LEFT"

   AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA IMMEDIATELY STARTS A DEVIATION TO THE LEFT ZONE

5. SCENARIO 005LT

   HIGH DEVIATION, IN THE MIDDLE RANGE ZONE ELICITING THE CALL "YOU'RE HIGH"

   AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS A DEVIATION TO THE VERY HIGH ZONE IN THE MIDDLE

6. SCENARIO 006LT

LOW DEVIATION, IN THE MIDDLE RANGE ZONE, ELICITING THE CALL "YOU'RE LOW"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS A DEVIATION TO THE LOW ZONE IN THE MIDDLE.

7. SCENARIO 007LT

RIGHT LINEUP DEVIATION, IN THE MIDDLE RANGE ZONE, ELICITING THE CALL "YOU'RE LINED UP RIGHT"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS A DEVIATION TO THE RIGHT ZONE IN THE MIDDLE

8. SCENARIO 008LT

LEFT DEVIATION, IN THE MIDDLE RANGE ZONE, ELICITING THE CALL "YOU'RE LINED UP LEFT"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO THE LEFT ZONE IN THE MIDDLE

9. SCENARIO 009LT

SLOW DEVIATION IN THE MIDDLE RANGE ZONE, ELICITING THE CALL "YOU'RE SLOW"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA CHANGES TO SLOW AOA IN THE MIDDLE

10. SCENARIO 010LT

FAST DEVIATION, IN THE MIDDLE RANGE ZONE, ELICITING THE CALL "YOU'RE FAST"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA CHANGES TO FAST AOA IN THE MIDDLE

11. SCENARIO 011LT

HIGH, FAST DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA CHANGES TO FAST AOA AND STARTS DEVIATION TO VERY HIGH ZONE IN CLOSE.

12. SCENARIO 012LT

LOW DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "POWER"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA CHANGES TO SLOW AOA AND STARTS DEVIATION TO THE LOW ZONE IN CLOSE.

13. SCENARIO 013LT

LOW, SLOW DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA CHANGES TO SLOW AOA AND STARTS DEVIATION TO THE LOW ZONE IN CLOSE

14. SCENARIO 014LT

LEFT LINEUP DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "RIGHT FOR LINEUP"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO THE LEFT ZONE IN CLOSE

15. SCENARIO 015LT

RIGHT LINEUP DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "LEFT FOR LINEUP"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO RIGHT ZONE IN CLOSE

16. SCENARIO 016LT

HIGH, RIGHT DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINE-UP, AOA: STARTS DEVIATION TO THE VERY HIGH AND RIGHT ZONES IN CLOSE

17. SCENARIO 017LT

LOW, LEFT DEVIATION, IN CLOSE RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE. LINEUP, AOA STARTS DEVIATION TO THE LOW AND LEFT ZONES IN CLOSE.

18. SCENARIO 018LT

HIGH DEVIATION, AT RAMP RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO VERY HIGH ZONE AT THE RAMP.

19. SCENARIO 019LT

LOW, DEVIATION, AT RAMP RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO THE LOW ZONE AT THE RAMP

20. SCENARIO 020LT

RIGHT DEVIATION, AT RAMP RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO RIGHT ZONE AT THE RAMP.

21. SCENARIO 021LT

LEFT DEVIATION, AT RAMP RANGE ZONE, ELICITING THE CALL "WAVEOFF"

AIRCRAFT STARTS ON GLIDESLOPE, LINEUP, AOA STARTS DEVIATION TO THE LEFT ZONE AT THE RAMP

22. SCENARIO 022LT

SLIGHT DEVIATIONS; LINEUP AND GLIDESLOPE START, MIDDLE

NO CALLS EXPECTED

23. SCENARIO 023LT

SLIGHT DEVIATIONS GLIDESLOPE AND LINEUP; START, MIDDLE

NO CALLS EXPECTED

24. SCENARIO 024LT

SLIGHT DEVIATIONS; LINEUP AND GLIDESLOPE; START, MIDDLE, CLOSE

NO CALLS EXPECTED

25. SCENARIO 025LT

SLIGHT DEVIATIONS, GLIDESLOPE AND LINEUP; START, MIDDLE, CLOSE

NO CALLS EXPECTED.

26. SCENARIO 026LT

SLIGHT DEVIATIONS, LINEUP AND GLIDESLOPE; START, MIDDLE, CLOSE

NO CALLS EXPECTED

27. SCENARIO 027LT

SLIGHT DEVIATIONS GLIDESLOPE AND LINEUP; START, CLOSE

NO CALLS EXPECTED

28. SCENARIO 028LT

SLIGHT DEVIATION; GLIDESLOPE AND LINEUP; START, MIDDLE, CLOSE

NO CALLS EXPECTED

29. SCENARIO 029LT

"OKAY" PASS (ON GLIDESLOPE, LINEUP, AOA THROUGHOUT)

MEDIUM PILOT DEVIATIONS WITHIN THE "ON" ZONES

NO CALLS EXPECTED

30. SCENARIO 030LT

"OKAY" PASS (ON GLIDESLOPE, LINEUP, AOA THROUGHOUT)

VARIED PILOT DEVIATIONS WITHIN THE "ON" ZONES

NO CALLS EXPECTED

TESTING SCENARIOS

THE FOLLOWING SCENARIOS ARE DESIGNED FOR TESTING THE GENERALIZABILITY OF SIMPLE "WAVING" SKILLS ACQUIRED WITH LAB TRAINING SCENARIOS TO MORE COMPLEX "WAVING" SITUATIONS. THE SCENARIOS ARE BASED ON "TYPICAL" ERROR TREND PROFILES, SEVERAL OF WHICH CAN LEAD TO RAMP STRIKES AND BOLTERS IN ACTUAL OPERATIONS.

ACTUAL CALLS ELICITED BY THESE SCENARIOS ARE DEPENDENT UPON TRAINEE ACTION DURING THE APPROACH. IN OTHER WORDS, THE ACTUAL PROFILE FLOWN MAY DIFFER FROM ITS DESIGN DUE TO THE TIMING AND CORRECTNESS ASPECTS OF TRAINEE CALLS. THE DESCRIPTIONS BELOW ARE PROFILE DESIGNS WHICH MAY ONLY OCCUR IF THERE IS NO TRAINEE INTERACTION

1. SCENARIO 001PT

    LINED UP A LITTLE RIGHT AT START
    LINED UP RIGHT IN MIDDLE, IN CLOSE
    LINED UP LEFT AT RAMP

2. SCENARIO 002PT

    SLOW IN MIDDLE, LOW IN MIDDLE
    LOW, FAST IN CLOSE, AT RAMP

3. SCENARIO 003PT

    LITTLE HIGH START
    HIGH IN MIDDLE
    LOW AT RAMP

4. SCENARIO 004PT

   LITTLE HIGH IN MIDDLE, IN CLOSE
   LOW AT RAMP

5. SCENARIO 005PT

   LITTLE LOW, LINED UP RIGHT AT START, IN MIDDLE
   LOW IN CLOSE ON LINEUP CORRECTION
   LOW AT RAMP

6. SCENARIO 006PT

   LITTLE LOW AT START, IN MIDDLE
   HIGH, FAST IN CLOSE, AT RAMP

7. SCENARIO 007PT

   LITTLE LINED UP LEFT IN MIDDLE
   LINED UP RIGHT IN CLOSE, AT RAMP

8. SCENARIO 008PT

   LOW AT START, IN MIDDLE
   LOW, SLOW IN CLOSE, AT RAMP

9. SCENARIO 009PT

   LITTLE HIGH IN MIDDLE
   SLOW IN MIDDLE
   LINED UP RIGHT IN CLOSE
   LOW, LINED UP RIGHT IN CLOSE, AT RAMP

10. SCENARIO 010PT

   LINED UP LEFT AT START, IN MIDDLE
   SLOW IN MIDDLE
   LOW IN CLOSE, AT RAMP

APPENDIX B

LSC SOFTWARE QUESTIONNAIRE

NAME ____________________ DATE __________

ORGANIZATION ____________________

TITLE __________

DESCRIBE YOUR EXPERIENCE [illegible] TO LSC JOB

____

____

[illegible] ________

[illegible] ________

1. Which aspects of the training session helped you learn the [illegible] task best?

___ Session briefing
___ Experimental info handout
___ Interacting with system

2. Which aspects of the session helped you the least?

___ Session briefing
___ Experimental info handout
___ Interacting with system

3. Which mode of system interaction helped you learn most effectively?

___ [illegible] with [illegible]
___ [illegible]
___ [illegible]
___ [illegible] except [illegible]

4. [illegible] training session [illegible] interfered with learning? ___ If yes, why?

____

____

____

5. [illegible] any aspect of the [illegible]

____

____

____

6. Rate how easily you were able to detect deviations by range zones:

1 = very easy　　3 = slightly difficult
2 = fairly easy　　4 = very difficult or impossible
(leave blank if not applicable this session)

		Start	Middle	Close	Ramp
Glideslope	- High				
	Low				
Line up	- Right				
	- Left				
AOA	- Fast				
	- Slow				

7. Which situation and voice call combinations did you feel you learned best during <u>this training session</u>? Which do you feel you learned least? (Mark your top two bests with Xs and your bottom two leasts with Os)

____ high/low at start --- "you're high/low"
____ lined up right/left at start --- "you're lined up right/left"
____ high/low in middle --- "you're high/low"
____ lined up right/left in middle --- "you're lined up right/left"
____ fast/slow in middle --- "you're fast/slow
____ high in close --- "you're high"
____ low in close --- "power"
____ lined up right/left in close --- "left/right for line up"
____ slow in close --- "power"
____ high/low at ramp --- "waveoff"
____ lined up right/left at ramp --- "waveoff"
____ fast/slow at ramp --- "waveoff"
____ high and fast in close --- "waveoff"
____ low and slow in close --- "waveoff"
____ high and lined up right in close --- "waveoff"
____ low and lined up left in close --- "waveoff"

8. Other comments about this session? ____________________
____
____

These questions are concerned with the total experiment:

9. Rate how well you learned the experimental LSO skills:

____ high and fast in close -------------------- WAVEOFF
____ low in middle ------------------------------ YOU'RE LOW
____ lined up left at start -------------------- YOU'RE LINED UP LEFT
____ low at ramp -------------------------------- WAVEOFF
____ lined up left in close -------------------- RIGHT FOR LINEUP
____ low start ---------------------------------- YOU'RE LOW
____ high in middle ----------------------------- YOU'RE HIGH
____ slow in middle ----------------------------- YOU'RE SLOW
____ lined up right in close ------------------- LEFT FOR LINEUP
____ high at ramp ------------------------------- WAVEOFF
____ low in close ------------------------------- POWER
____ fast in middle ----------------------------- YOU'RE FAST
____ lined up left in middle ------------------- YOU'RE LINED UP LEFT
____ lined up right at ramp -------------------- WAVEOFF
____ low and slow in close --------------------- WAVEOFF
____ lined up right at start ------------------- YOU'RE LINED UP RIGHT
____ low and lined up left in close ------------ WAVEOFF
____ lined up right in middle ------------------ YOU'RE LINED UP RIGHT
____ high and lined up right in close ---------- WAVEOFF
____ high start --------------------------------- YOU'RE HIGH
____ lined up left at ramp --------------------- WAVEOFF

For the items above rate how well you learned each situation/call combination. Use the scale below:

1 = learned very well
2 = learned
3 = not sure if learned
4 = probably not learned
5 = definitely not learned

10. After going through this experimental LSO training program, do you feel that you actually have a better conceptual understanding of the LSO's "waving" job? ____ If yes, do you feel that using the experimental system was the major factor in your learning experience (as opposed to picking up "waving" concepts through briefings and discussions this week)? _____

11. Do you think this system would be an effective part of introductory LSO decision training? _____ Why/why not?

____

____

____

12. What suggestions do you have for improving the conduct of this experiment?

____

____

____

13. Any other final comments? _______________________________

____

____

APPENDIX C

AWAVS EXPERIMENTATION

The AWAVS simulation at NAVTRAEQUIPCEN was used for experimental investigation of visual simulation requirements for an LSO training system. In this appendix, the original experimental design is presented, followed by a description of actual activities and experimental results. The original experimental design is presented essentially as it appeared in a project progress report of December 1978, as historical perspective to what actually occurred.

ORIGINAL EXPERIMENTAL DESIGN

The LSO training system will include a visual display for depicting the incoming aircraft. Some of the characteristics of this display are not specifiable in an a priority manner and therefore require empirical investigation in order to specify certain parameters as they relate to LSO job functions. The experiments that involve AWAVS equipment are designed to address three basic issues about visual system functional requirements. The first issue concerns the display resolution required for acceptable LSO performance. The second issue involves the level of detail needed in the depiction of the target aircraft to obtain adequate LSO performance. The last issue to be addressed concerns the effect of field of view (FOV) information on LSO performance in a visual simulation.

<u>Method - Experiment 1</u>. Design: This experiment will involve a five variable randomized block factorial design. The first variable to be considered is resolution. That is, resolution measured in terms of the number of raster lines utilized in projecting the target (A-7) image. The target projector of AWAVS will be operated in its zoom mode (i.e., not a fixed area projection). The second variable is the simulated ambient light condition (day/night) of the approach scenario. Two levels of this variable will be considered, one representing a day scene and the other representing a night scene. Distance from touchdown when a significant deviation occurs is the third variable to be manipulated. This variable is to be manipulated as a series of four range zones corresponding to the zones commonly referenced by LSOs as:

1. At-the-start (4000-6000 ft. from the #3 wire)
2. In-the-middle (2200-4000 ft. from the #3 wire)
3. In-close (600-2200 ft. from the #3 wire)
4. At-the-ramp (0-600 ft. from the #3 wire)

Variable four concerns the level of detail to which the target aircraft [illegible] be rendered. Two levels of this variable will be manipulated. The [illegible] level will be the best and most realistic aircraft representation AWAVS is capable of displaying. The second level will be an aircraft representation which is best described as a "wire aircraft" where only the [illegible] of the aircraft surfaces are displayed. This level includes a hidden [illegible] capability so that the representation appears as a solid [illegible]. The fifth and last variable that will be manipulated in this experiment is subjects. This variable is a random variable. Level of detail, distance to touchdown, day/night, and resolution level are all fixed variables. Figure C-1 graphically depicts the design.

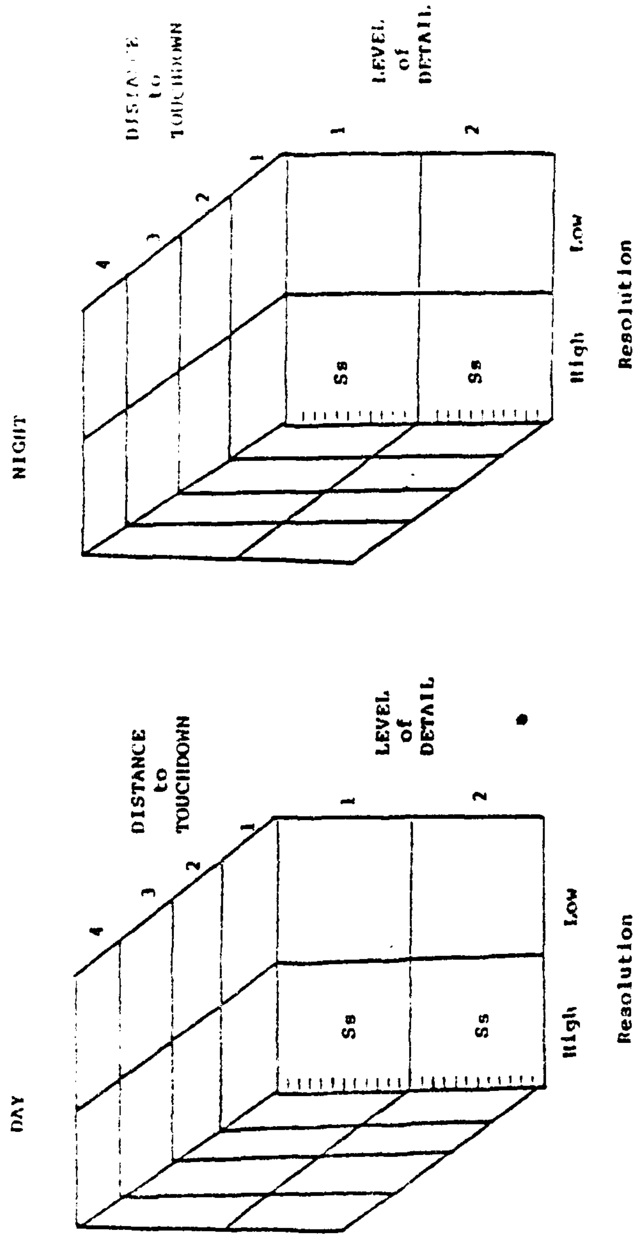

Figure C-1. Design for Experiment 1

Procedure: From the LSO's point of view the experimental task [illegible] resemble the waving task he performs while assisting [illegible] control [illegible] aircraft landings. The LSO will observe the aircraft [illegible] approach [illegible] make calls that indicate his perception of a deviant approach parameter. [illegible] this situation the aircraft will begin deviating from the ideal [illegible] and continue to deviate until: 1) the LSO makes a call [illegible] a pre-defined zone boundary. When either of these [illegible] display will blank for five seconds. Following [illegible] resume the approach from the zone boundary and [illegible] no further large deviations from the glideslope. [illegible] delay after an approach has been completed before the next approach [illegible]

Thus the LSO's task is to observe the display and make an appropriate [illegible] The subject's performance will be assessed as to the [illegible] accuracy [illegible] call and when the call is made. In addition, the subject will [illegible] as to the reasons for his calls, his subjective impressions of the [illegible] etc. We would also like to monitor the subject's eye movements. The [illegible] ment of when the call is made should begin when the [illegible] and [illegible] at the onset of the response. The response measure should be to the [illegible] second level to allow for an accurate comparison between groups and accurate assessment of the appropriate aircraft parameters. The use of a voice activated switch will facilitate the measurement of the timing and recording of the response. When an approach is completed the LSO will be asked a few pertinent questions concerning the approach. Ten seconds later the next approach begins and the process is repeated The iteration continues for twenty approaches. Of these twenty approaches, ten feature an aircraft representation from the first level of detail and ten from the second level. The order of presentation of these various aircraft representations is to be random without replacement.

Within these twenty trials, the call range variable is manipulated with four profiles representing each zone. The remaining four approaches will be catch trials where the deviations that occur are slight and are not expected to elicit a call from the LSO. The order of presentation of these trials is to be random, again without replacement. Of the four trials for each range zone, two are to be with the finely detailed aircraft representation and two with the "wire aircraft" representation. The same type of arrangement is expected for the catch trials.

A group of twenty trials constitutes a session and each session is run under single level of resolution. A single subject will be expected to wave five consecutive sessions. These five sessions will be referred to as a block of trials. The first session in each block is a warmup session to familiarize the LSO with the task. The warmup session is to be run under the same level of resolution as the first test session in that block. With regard to resolution level, one half of the subjects are to begin the test sessions at a high level and the other half at a low level. Thereafter, the level is to be manipulated across sessions in an ABBA manner for each subject.

The day/night variable must be balanced within subjects and across blocks of trials. Each subject is given four blocks of trials. Each block of trials will be run under either day or night conditions. Half the subjects will receive day conditions in the first block and half will receive night conditions. Thereafter, the order of day/night presentations will be governed by the ABBA balancing rule. Table C-1 presents a summary of the experimental procedure.

Subjects: Six randomly selected LSOs will serve as the subjects for this experiment. The LSOs should have attained at least a Wing LSO designation level and should be proficient (performed LSO duties within past year).

Apparatus: AWAVS, visual simulation research facility at NAVTRAEQUIPCEN.

Stimuli: An aircraft representation generated by the CGI portion of AWAVS will be used as the primary stimuli for the experiment. Two aircraft images will be used as discussed above. The set of approach profiles will be designed by Logicon. The background field of view is to be set at its maximal setting and is to include the carrier deck outline, horizon, ship's wake, arresting wires and deck markings. The optimum aircraft touchdown point should be within the viewing area.

Method - Experiment 2. Design: Experiment 2 utilizes a four variable, randomized block design similar to the design of Experiment 1. Three of the variables are the same as those found in the first experiment: day/night, range zone and subjects. In this experiment, field of view is substituted for resolution and level of detail. The field of view (FOV) variable is a fixed variable with three levels of consideration, each corresponding to a specific informational component. The first level of this variable contains the maximum amount of referent information including the deck wires, the touchdown zone, the deck with the lineup stripe, the deck outline, and the ship's wake. Condition two includes all of the above except the wire and the touchdown zone. This condition contains information to help the LSO with lineup (the centerline, the deck outline and the wake), but it does not provide information concerning the touchdown referent or the feedback from the aircraft catching the wires. The last level of this variable is the most informationally impoverished condition in that only the port aft corner of the ramp and the ship's wake is available to the LSO. Level three corresponds approximately to the FOV available in a single CRT visual system and level two approximates the FOV of a two CRT visual system. In all conditions a portion of the FOV is allocated to the right of the LSOs line of sight to include the ship's wake and area of likely aircraft deviation. The experiment will be run using the highest resolution AWAVS can muster, and the target will be depicted with the most detail possible. Figure C-2 graphically presents the design.

Procedure: The procedure in this experiment is similar to the procedures in Experiment 1 in that we are again dividing up the experiment into blocks, sessions and trials (approaches). This time each session will include five approach profiles. These five approaches include one with a deviation in each of the four range zones and a catch trial with no significant deviations. The five trials that constitute a session will be run under a single FOV level. There will be ten sessions in a single block, one warmup session and nine test sessions. Each block is run as a day block or a night block. The experiment consists of four blocks, two night blocks and two day blocks.

Given that we have two blocks each for day or night conditions, and that each block contains nine test sessions, we can completely balance the order of FOV

TABLE C-1. PROCEDURE SUMMARY FOR EXPERIMENT 1

A) Experiment 1 = 4 blocks of trials/per subject

- Each block is run under either a day or night condition.

B) [illegible] subjects in the experiment

- Within subjects day versus night conditions is balanced across blocks (ABBA).
- Across subjects the day/night condition of the first block is balanced.

C) 1 block = 5 sessions

- 1 warmup session and 4 test sessions.
- Level of resolution is balanced across sessions (ABBA).
- Level of resolution of the first session is balanced across subjects.

D) 1 session = 20 approaches (100 approaches per block)

- 100 approach profiles will be generated with 20 profiles being randomly assigned to each session.

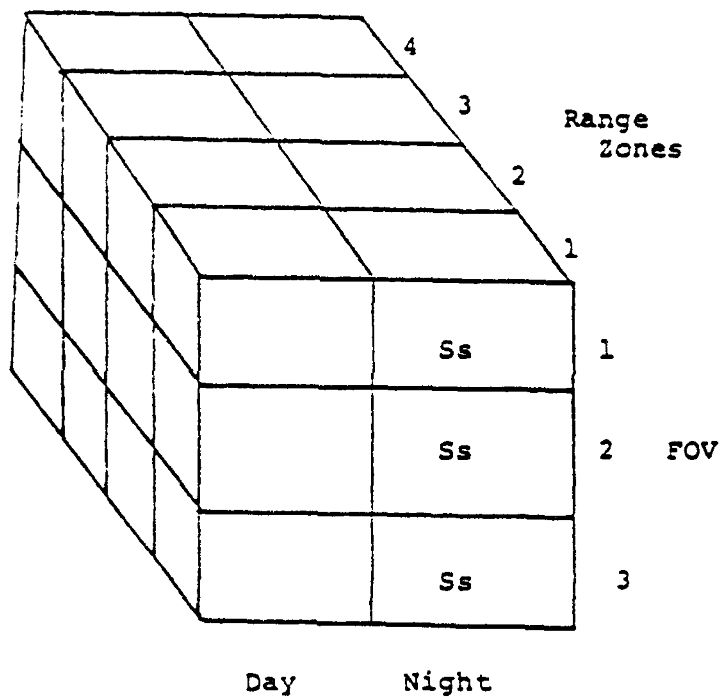

Figure C-2. Design for Experiment 2

levels (3!) across the two blocks. Naturally, the sequence of condition orders must also be balanced across subjects. For example, if we assign the FOV level order 1, 2, 3 to the name A and

2, 3, 1 - B
3, 1, 2 - C
1, 3, 2 - D
3, 2, 1 - E
2, 1, 3 - F

then we can proceed to balance the presentation of these orders across subjects using a latin square procedure.

Subjects: Twelve subjects are required. Each subject must meet the same standards as described in Experiment 1.

Apparatus: Same as Experiment 1.

ACTUAL EXPERIMENT AND RESULTS

Unfortunately, these experiments were not conducted as originally planned. The AWAVS device was not capable of handling many of the variables. Resolution turned out to be a meaningless dimension in the AWAVS environment since the best resolution possible was barely adequate for the task. The next best level of resolution was totally inadequate in an LSO context. The day-vs-night variable was also dropped since the simulation was not equipped to show a night scene or a night aircraft image. Level of detail variation was also beyond the simulation's capability since only one aircraft image was available. The distance from touchdown variable was discarded since the target projector had to remain fixed in a single position. In addition, it was discovered that the software which controlled the target aircraft only allowed a straight-vector line approach. That is to say, once the aircraft started on an approach vector it would not accept a modification of that vector during the approach. There was no method of randomly selecting approach profiles in real time. The sequence of approaches had to be recorded prior to the start of the experiment. All of these constraints led to a single experiment which is described below.

Design. The major independent variables were:

1. Field of View - The field of view was as described in Experiment 2 above, and accomplished by means of taping a sheet of cardboard over the appropriate portion of the background projector lens. Three levels of background field of view were used. Each of these levels correspond to specific pieces of information that the LSO may use to calibrate his perceptual-decision making mechanism. The first level provides "complete" information by including the view from the deck wires to about 20 degrees right of the approaching aircraft, a viewing area of 160 degrees. The second level reduced the information by cutting out the landing area and the wires, limiting the field of view to about 90 degrees. The third level reduced the information still further to about a 45 degree field of view in the approach area.

2. Type of Deviation - Since only single vector approaches were possible, there were two types of deviations introduced, Lineup and Glideslope.

3. Size of the Deviation When the Approach Was Terminated - Since the approach could not be completed to touchdown, all approaches were terminated on LSO call or at a set distance (approximately 1500 feet) from touchdown if no call was made. The size of the deviation at that point was determined from positioning coordinates. There were four levels of this variable: large, medium and small, as well as, no deviation (a catch trial). Basis for deviation size was based on questionnaire data collected in an earlier study by Hooks and others (1978).

The dependent variables were:

1. The LSO Calls - The subjects were instructed to make calls to the aircraft, just as though they were actually waving the approach. No knowledge of results (touchdown information) was provided. The aircraft appeared, "flew" the profile and disappeared at the set range or on the voice call.

2. The LSO's Recall of the Deviations During the Approach - After each approach the subject was asked for a profile description, noting any portions of the approach where he felt the aircraft may have deviated from the ideal glideslope or lineup.

Stimuli: An aircraft representation generated by the CGI portion of AWAVS was used as the primary stimuli for the experiment. The AWAVS target image projection field of view was set at its maximal setting. The background field of view included the carrier deck outline, horizon, ship's wake, arresting wires, and deck markings. Thirty approach profiles were constructed for use in this experiment. The profiles were computer generated images of an A-7 flying an approach to a Forrestal-class aircraft carrier. The approaches differed from one another in two ways, the range at which the approach began and the type of deviation that occurred during the approach.

The start range and deviation types were designed to combine in a completely balanced manner. That is, each type of deviation began at each of the different start ranges. For example, the "high" glideslope deviation approach began at each of the three start ranges, resulting in three "high" glideslope deviation profiles. All profiles were terminated at 1500 feet from the touchdown point. Therefore the three "high" glideslope profiles each reflected differing amounts of deviation at this termination point. Catch trial approaches were also included. The start ranges for these approaches were keyed to those for approaches which had deviations. Within the thirty profiles, six had only glideslope deviations, six had only lineup deviations, and nine were combinations of glideslope and lineup deviations. There were nine catch trials.

Subject: Six experimentally naive LSOs spent two days in Orlando, Florida, to participate in the experiment.

Procedure: Each of the six subjects was run under all conditions of background field of view. The subject's task in this experiment was twofold. First, he observed the approach and made a call when the aircraft deviated far enough to require correction or warning. When the call was made, the approach [illegible] aircraft relative to the "ideal" position. [illegible] approaches [illegible] actual position was recorded when the approach was terminated.

[illegible] thereby [illegible], according to a latin square design, the order of presentation of [illegible] types of [illegible]. The [illegible] of the experiment [illegible] with [illegible] that was run under the same field of view condition [illegible] experimental block.

[illegible] were initiated and [illegible] through intercom signals from the [illegible] to the AWAVS system operator. The experimenter was located within [illegible] visual simulation's domed display area adjacent to the subject. At [illegible], the experimenter turned the aircraft image projector on and, at [illegible] turned it off. The subject was interrogated about perceived [illegible] prior to initiating the next approach.

[illegible] AWAVS Visual Simulation Research Facility at NAVTRAEQUIPCEN [illegible] a domed display area surrounding an aircraft cockpit. For this [illegible] cockpit windscreen was removed and the subject sat on an [illegible] seat above the cockpit seat.

[illegible] relating the probability of the LSO making a call as a [illegible] view, size of deviation and type of deviation are dis- [illegible]. An analysis of variances of these data revealed no [illegible] or interactions; the ANOVA table is presented in [illegible]-2. The data portrayed in Figure C-4 express the probability of the LSO [illegible] the aircraft deviated from the "ideal" glidepath during the [illegible] function of field of view, size of deviation and type of [illegible]. [illegible] of these data found one significant main effect [illegible] 138.8, p<.05. No significant interactions were [illegible] in Table C-3. A Scheffe's S method of [illegible] was used to test the differences in the means for the three [illegible] with the field of view variable (see Table C-4) [illegible] could be shown to be significant.

[illegible] was conducted on the [illegible] reported above. Data from [illegible] be pointed [illegible] very close to [illegible] significant [illegible] with F values [illegible]. Perhaps with more subjects or more data [illegible]

[illegible] trends within the data. [illegible] argument [illegible] where statistically significant [illegible]. Now we are faced with the problem of [illegible] enough portrayal of the LSO [illegible] the results of the experiment. Even under [illegible] AWAVS environment, that may be a tenuous proposition.

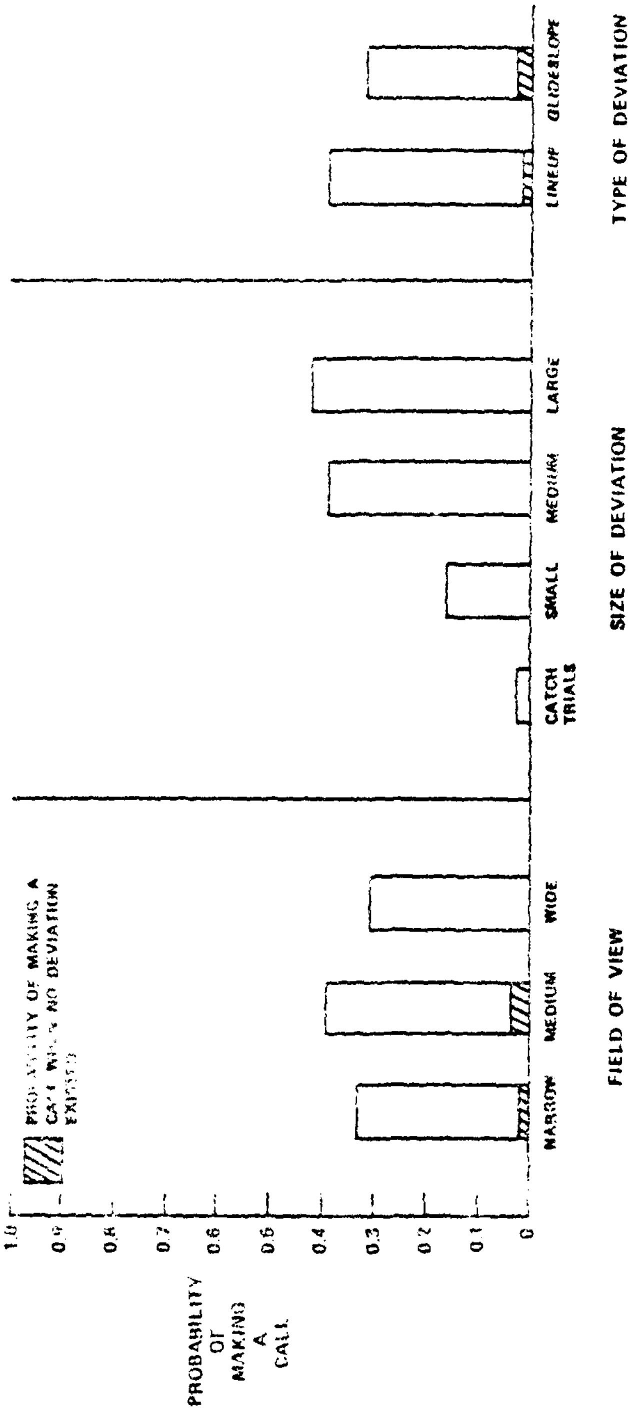

Figure C-3. Probability of Making a Call

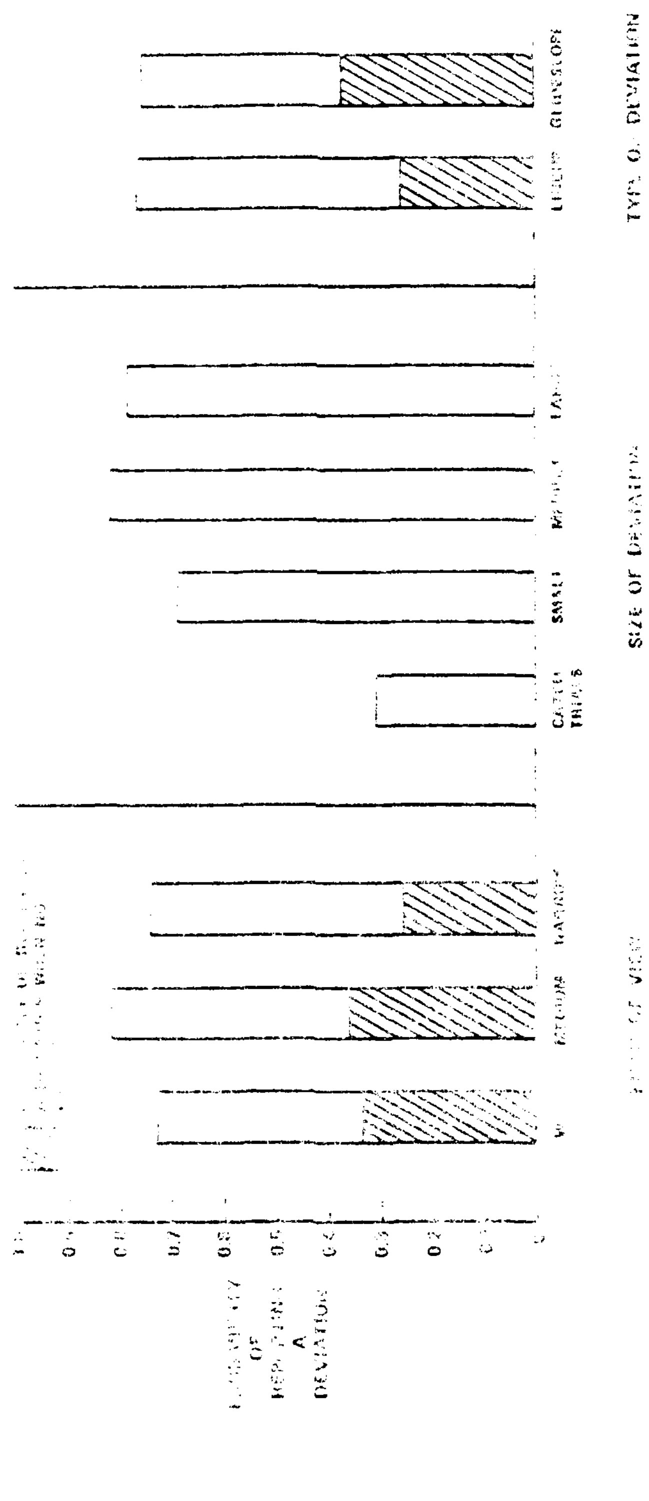

Figure C-4 Probability of Reporting Deviations

TABLE C-2. ANALYSIS OF VARIANCE TABLE - DATA RELATING THE PROBABILITY OF MAKING A CALL

Source	Sum of Squares	df	Mean Square	F
D (lineup vs. glideslope)	5306.7	1	5306.7	20.7
F (field of view)	3142.6	2	1571.3	4.8
B (size of deviation)	1212.8	3	404.3	1.01
S (subjects)	3483.0	4	870.8	--
D x S	1025.9	4	256.5	--
F x S	2607.4	8	325.9	--
B x S	4789.4	12	399.1	--
D x F	1405.9	2	702.9	1.84
D x B	2494.4	3	831.5	0.87
F x B	2491.5	6	415.2	0.64
D x F x S	3054.2	8	381.8	--
D x B x S	11518.3	12	959.9	--
F x B x S	15468.5	24	644.5	--
D x F x B	25497.3	6	4249.5	0.93
D x F x B x S	110024.4	24	4584.4	--
Total	193522.3	119		

TABLE C-3. ANALYSIS OF VARIANCE TABLE - DATA RELATING THE PROBABILITY OF REPORTING A DEVIATION

Source	Sum of Squares	df	Mean Square	F
D (lineup vs. glideslope)	2930.4	1	2930.4	21.0
F (field of view)	4727.[illegible]	2	2363.9	21.[illegible]
B (size of deviation)	4589.[illegible]	3	1530.0	7.9
S (subjects)	1111.[illegible]	4	277.[illegible]	--
D x S	557.4	4	139.3	--
F x S	886.2	8	110.8	--
B x S	2303.6	12	192.0	--
D x F	1389.[illegible]	2	694.6	1.6
D x B	10499.[illegible]	3	3499.9	8.[illegible]
F x B	7694.5	6	1282.4	3.[illegible]
D x F x S	3472.0	8	434.0	--
D x B x S	5052.5	12	421.0	--
F x B x S	[illegible]	24	358.4	--
D x F x B	20576.9	6	3429.5	8.16
D x F x B x S	525067.9	24	21577.8	--
Total	[illegible]	119		

TABLE C-4. DIFFERENCES AMONG MEANS [illegible] TREATMENT LEVELS FOR THE FIELD OF VIEW MAIN EFFECT

	Wide	Medium	Narrow
Wide	--	[illegible]	[illegible]
Medium	--	--	.07
Narrow	--	--	--

APPENDIX D

EXPERIMENTAL PROTOTYPE LSO TRAINING SYSTEM

This appendix describes the performance capabilities recommended for an experimental prototype LSO training system. The capabilities are organized in the same functional structure reported by Hooks and others (1978). Figure D-1, excerpted from that report, is provided as an organizational aid for the review of information presented below.

INSTRUCTIONAL PRESENTATION

The instructional presentation aspect of the system involves presentation of cues which enable trainee task performance and promote the learning of LSO skills and knowledges. The functional elements are described below.

<u>Visual Environment</u>. Field of view should encompass the continuum from approach corridor through the touchdown zone.

a. Approaching Aircraft (under LSO control)

(1) aircraft types: A-6, A-7, E-2, F-14, S-3 (these are the primary fleet aircraft; others which have been left out are not considered necessary for experimentation).

(2) position lights; red, green and white lights located on different parts of the aircraft; positioning of the lights varies by aircraft type; intensity and operability of individual lights under instructional control of the system.

(3) AOA lights: red, amber and green lights located on front portion of aircraft (usually the nose wheel strut area); intensity of the lights and operability of individual lights under instructional control of the system; lights correlated to aircraft speed.

(4) aircraft dynamics: pitch, roll, yaw angles; speed.

b. Operating Environment

(1) ambient light: night conditions.

(2) weather effects: reduced visibility, ceiling.

(3) horizon definition: continuum from well-defined to non-existent.

(4) plane guard destroyer: ship positioned approximately [illegible] mile behind carrier; red mast lights.

c. Aircraft Carrier

(1) deck outline: deck edge in LSO field of view: only one carrier needs to be modelled.

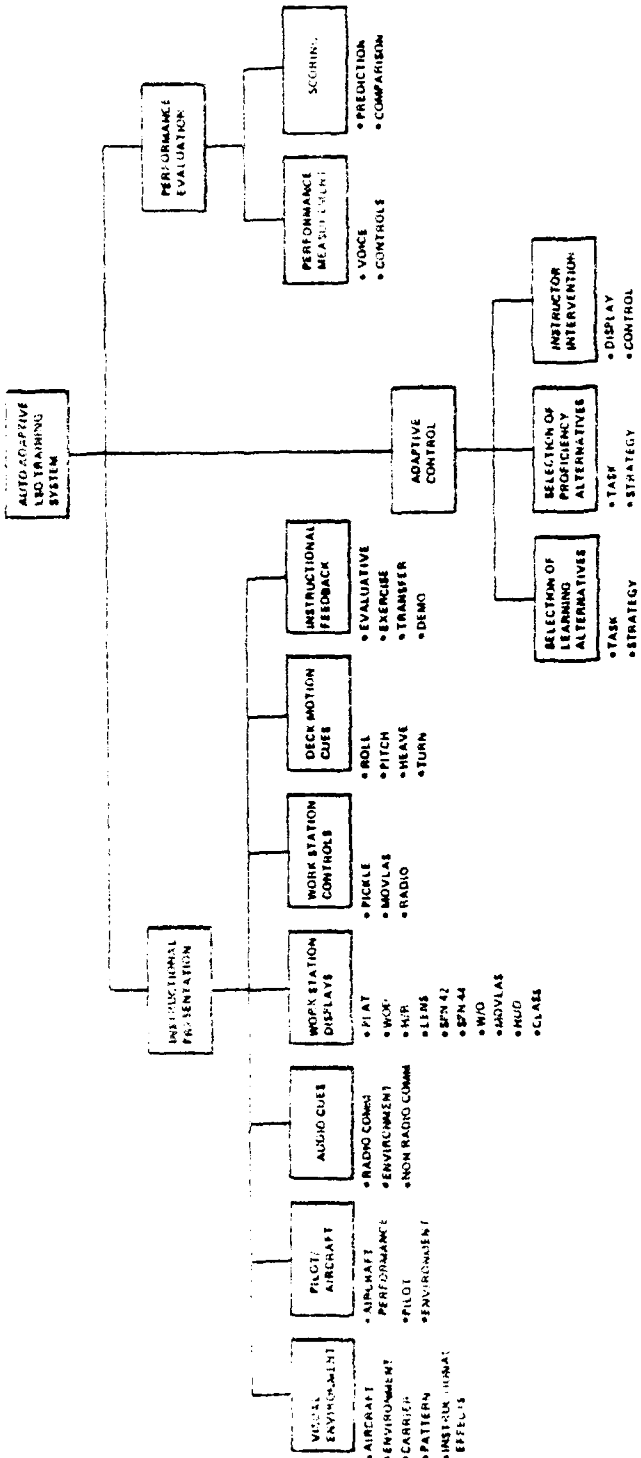

Figure D-1. Generic LSO Training System Functions

(2) deck lighting [illegible]

(3) deck status lights [illegible] red and green lights [illegible] foul deck status) in LSO [illegible] of view; variable intensity and [illegible]

(4) LSO platform positioning: [illegible] with modeled carrier; [illegible] platform should be recessed (for a [illegible] carrier [illegible] platform should be flush with deck).

d. Instructional Effects

(1) alphanumerics: for data presentation; display under instructional control.

(2) graphic depictions: [illegible] and exaggerated [illegible] perceptual cueing of optimum [illegible] of MOVLAS positioning; display under instructional control [illegible] system.

Pilot/Aircraft. Control of pilot/aircraft dynamics and LSO/pilot interaction should be available from two independent sources, instructor-controlled "joystick" and computer simulation.

a. Aircraft Performance Characteristics

(1) aircraft types: as indicated in Visual Environment

(2) flight characteristics: pitch, roll, yaw, speed

[illegible] capabilities: vertical, lateral, acceleration, [illegible] and waveoff responsiveness

[illegible]

[illegible] continuum of skill levels from low to [illegible] in terms of both under-control, over- [illegible] facility.

[illegible] control [illegible] individual [illegible] glideslope, lineup, speed [illegible] control.

[illegible] to [illegible] from no response to [illegible], including incorrect responses.

[illegible] effects: wind speed and direction

[illegible]

[illegible] given by LSO through hand-held device and [illegible] pilot's "meatball" call required; can be instructor or [illegible] simulated

b. Environmental sounds

(1) engine of approaching aircraft: variations in pitch and intensity correlated to range and pilot throttle control; interactive with approach situation.

(2) deck noises: aircraft and flight deck vehicles; non-interactive.

c. Instructor/student communications

Workstation Displays.

a. WOD Indicator: wind speed and direction relative to ship heading.

b. Hook-to-Ramp Indicator: dynamically shows relative positioning of ramp to optimum glideslope.

c. FLOLS Indicators: basic angle and roll angle

d. SPN-42 Radar Indicators: speed (true or closure), line-up deviations, glideslope deviations.

e. Waveoff Indicator: red light near LSO console indicative of waveoff light activation.

f. MOVLAS Position Indicator: indicative of MOVLAS signal positioning.

Workstation Controls.

a. "Pickle": hand-held device for activating waveoff and cut lights.

b. MOVLAS Control: hand-operated lever for signalling perceived (LSO) glideslope position of aircraft and inducing pilot responses.

c. Radio: hand-held voice transmit-receive device for radio communications.

Deck Motion Cues.

a. Roll: dynamic rotation and static positioning (trim) about longitudinal axis of ship.

b. Pitch: dynamic rotation and static positioning (trim) about lateral axis of ship.

Instructional Feedback.

a. Evaluative Feedback scoring, diagnosis and specific performance information, situation record/replay; freeze.

b. Demonstration: presentation of ideal performance and typical performance errors, through "canned" approaches.

ADAPTIVE CONTROL

Adaptive control involves the selection and control of conditions and situations tailored to the instructional needs of the trainee. Both automated and manual elements are described below.

Selection of Learning Alternatives.

a. Task Selection: selection of the next skill to be learned or practiced, based on prior performance.

b. Instructional Strategy Selection: selection of the exercises and/or instructional effects which promote learning of the skill selected.

Instructor Intervention. Functions enabling the instructor to act as an adaptive training controller.

a. Display: information concerning instructional strategy, exercise conditions, trainee performance; to include repeater of student view of approach.

b. Control: manual control of information accessibility and exercise conditions (visual, pilot/aircraft, audio, trainee workstation displays/controls, deck motion and instructional effects as described earlier).

PERFORMANCE EVALUATION

Functional support for evaluation of perceptual, decision-making and response skills.

Performance Measurement.

a. Voice Calls: extraction of speech recognition data relevant to LSO radio voice calls.

b. Control Activations: extraction of data relevant to LSO control activations (MOVLAS, waveoff lights, cut lights, radio).

c. Aircraft Data: extraction of aircraft positioning and state information.

d. Instructor Grading: manual instructor-generated grading inputs.

Scoring.

a. Performance Predictions: specification of predicted LSO performance relative to exercise conditions.

b. Performance Comparison: comparison of performance measurement data and instructor grading to predicted performance.

NAVTRAEQUIPCEN 78-C-0071-1

DISTRIBUTION LIST

Commanding Officer
Naval Training Equipment Center
Orlando, FL 32813

Defense Technical Information Center
Cameron Station
Alexandria, VA 22314 12

(All other addressees receive one copy)

Chief of Naval Operations
OP-987H
Attn: Dr. R. G. Smith
Washington, DC 20350

Chief of Naval Operations
OP-115
Research, Development and Studies
Room 0G36
Washington, DC 20350

Commander
Naval Air Systems Command
AIR 413F
Washington, DC 20361

Dr. Henry M. Halff
Office of Naval Research
Code 458
Arlington, VA 22217

Navy Personnel Research and Development Center
Attn: [illegible] McDowell
[illegible] Code P2[illegible]
San Diego, CA [illegible]

Commander
Naval Air Development Center
Attn: Code 6022
Warminster, PA 18974

[illegible] Psychology Department
Naval [illegible] Medical Research Lab (L53)
Naval Air Station
Pensacola, FL 32508

Commander
Naval Weapons Center
Code 3154
Attn: Mr. [illegible] Curtis
China Lake, CA 93555

Chief of Naval Air Training
Attn: Code 333
Naval Air Station
Corpus Christi, TX 78419

Scientific Advisor
Headquarters US Marine Corps
Washington, DC 20380

US Air Force Human Resources Lab
TSZ
Brooks AFB, TX 78235

US Air Force Human Resources Lab
AFHRL-FT
Flying Training Division
Attn: Dr. Edwards
Williams AFB, AZ 85224

Commander
Naval Air Force
US Pacific Fleet (Code 342)
NAS North Island
San Diego, CA 92135

US Air Force Human Resources Lab
AFHRL-MPM
Manpower & Personnel Division
Manpower & Force Management Systems [illegible]
Brooks AFB, TX 78235

Commander
Naval Air Force
US Pacific Fleet (Code 31[illegible]
NAS North Island
San Diego, CA [illegible]

Chief
ARI Field Unit
P. O. Box 476
Ft Rucker, AL 363[illegible]

AFHRL/OTO
Luke AFB, AZ 85309

US Air Force Human Resources Lab
AFHRL-OT
Operational Training Division
Williams AFB, AZ 85224

Commanding Officer
US Army Security Agency Training Center
Library
Ft. Devens, MA 01433

Dr. Jesse Orlansky
Institute for Defense Analyses
Science and Technology Division
400 Army-Navy Drive
Arlington, VA 22202

Dr. Donald Connolly
Research Psychologist
Federal Aviation Administration
FAA NAFEC ANA-230 Bldg. 3
Atlantic City, NJ 08405

Chief
Methodology and Standards Staff
Federal Aviation Administration
Academy
Aeronautical Center, AAC - 914
P. O. Box 25082
Oklahoma City, OK 73125

DATE

FILMED

8 8